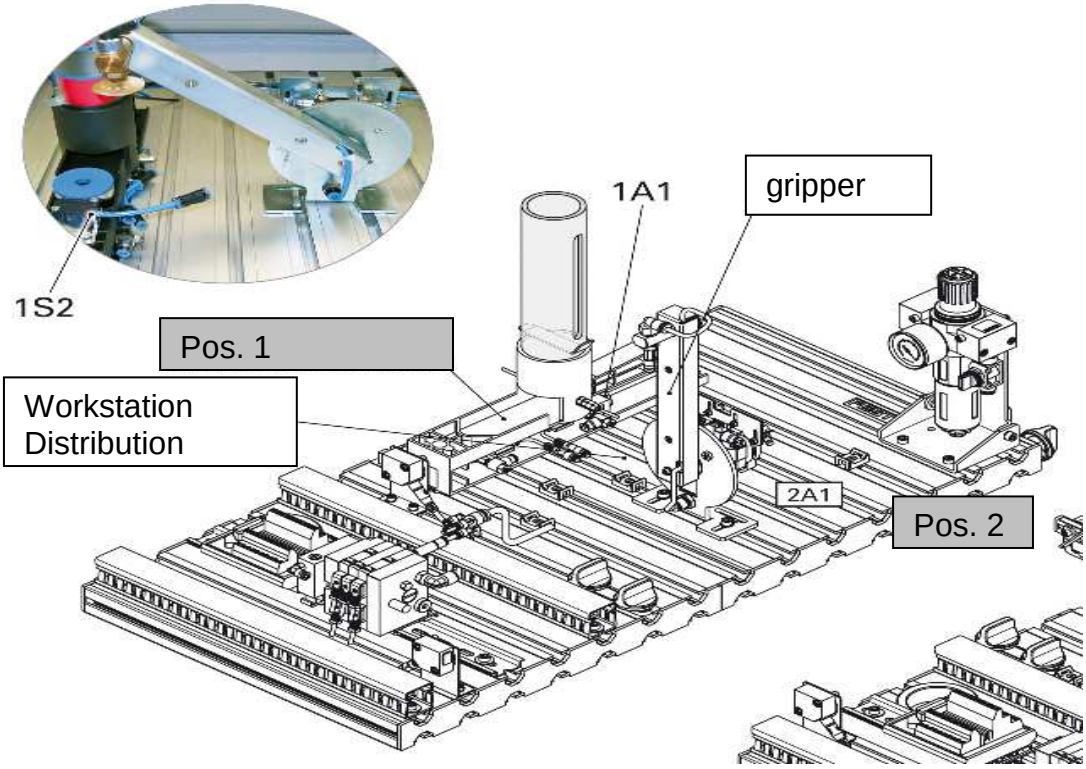
This action based training was developed within the Leonardo Da Vinci Transfer of Innovation Project:

“MODULES FOR VOCATIONAL EDUCATION AND TRAINING FOR COMPETENCES IN EUROPA II”

“MOVET II”

(PROJECTNUMBER **DE/10/LLP-LdV/TOI/147341**)

Module Electro-Pneumatics



The aim of the training is to enable the apprentices to develop the skills, knowledge and competence for competence area 7 of the competence Matrix Mechatronics from the VQTS model (cf. Karin Luomi-Messerer & Jörg Markowitsch, Vienna 2006)

7.2 He/She can master the selection of hardware, software and industrial components for mechatronic systems (sensors, actuators, valves, relays, interfaces, communication procedures). He/she can provide and test simple software control programs (SPS) and develop and design simple control programms according to production process requirements (adaption of 7.2)

Overview of the Module

Allocation in the competence Matrix “Mechatronics”

Competence area	Steps of competence development					
1. Maintaining and assuring the reliability of mechatronic systems	He/She can perform the basic scheduled maintenance on mechatronic machines and systems and adhere to the equipment maintenance plans.	He/She can master the maintenance procedures for mechatronic systems such as the use of service documents and maintenance plans and, if faced with new challenges, can make the necessary adaptations.	He/She can use preventive maintenance to assure the trouble-free operation of mechatronic systems. In addition, he/she can modify operational sequences to implement quality-assurance measures	He/She can develop the necessary procedures for maintenance of mechatronic devices and systems, and can schedule the maintenance and quality-assurance procedures.		
2. Installing and dismantling mechatronic systems and facilities	He/She can use written instructions to install and dismantle individual components (sensors, actuators, drives, motors, transport systems, racks) that form a functional group of mechatronic systems.		He/She can master the installation and dismantling of mechatronic systems that use several technologies (mechanics, hydraulics, pneumatics, electricalmechanics, electronics), set up the connexion technology, and check the efficiency of the overall system.		He/She can provide independent mechatronic solutions for the construction of production lines, assure their overall ability to function, and, in addition, can use both existing and modifi ed standard components.	
3. Installing and adjusting mechatronic components in systems and production lines	He/She is able to install and adjust standardized mechatronic components, e.g. individual electro-pneumatic valves, sensor and actuator units.		He/She can install and adjust components of mechatronic subsystems (e.g., linear drives, measuring systems, transport systems).		He/She can install and adjust complex mechatronic facilities that include diverse technologies and instrumentation and control (I&C) equipment, adjust the associated parameters, test the facilities overall functions, and assure their reliability	
4. Designing, adapting, and building mechatronic systems and facilities on the basis of client needs and site plans	He/She can use machine tools controlled either manually or via computer-program to fabricate (according to production designs and customer requirements) the individual components for mechatronic systems. He/she can provide simple designs and descriptions of mechatronic subsystems and can use basic CAD applications.	He/She can build simple mechatronic subsystems by using eineering drawing and can install he devices according to specific production needs. He/She can act on extensive knowledge of standards and regulations (e.g. on surface treatments) and is able to use CAD’s more advanced functions (e.g. interference check).	He/She can build mechatronic systems by using both original construction techniques and previously designed parts. He/She fully understands CAD functions and can document system developments (parts lists, descriptions of function, operating instructions).	He/She can design and build autonomous mechatronic subsystems and, with suitable measuring and testing facilities, can assess the necessary production accuracy. He/She can document the results with quality-control systems.	He/She can make independent adaptations to the various devices (including selection of drives, sensors, SPS) and can use CNC programs for building the system. He/She can, through a digital mock up, assemble and simulate the functioning system and use computeraided computations (e.g. FEM). He/She can perform cost-benefi t analyses (e.g. as a basis for deciding whether components should be bought or individually constructed.)	He/She can independently develop complex mechatronic systems and can calculate the economic usefulness of the system. He/She can optimise CNC programs for the manufacturing of complex mechatronic devices and systems and monitor the automated quantity of an open loop control system.

5. Putting mechatronic systems into operation and providing clients with technical and economic support	He/She can, according to specifications and blueprints, put mechatronic devices into operation and provide support to the client in the handover phase.	He/She, after considering the enterprise's needs and basic conditions, can put the mechatronic systems into operation, create the necessary documentation, advise the customer on safe operations of the devices, and advise on future technology selection.	He/She, after considering all basic conditions, can master the start-up of interconnected mechatronic systems and machines, and can provide the necessary documentation including a manual. He/She can review client needs and confi gure machines that provide solutions. He/She can train the customer where necessary and provide support for safe operating procedures.	He/She can evaluate customer requirements for mechatronic facilities, develop solutions, and can plan the system's implementation and operation.	He/She can direct, including scheduling and time management, the start-up of the project from the creation of a proposal to the client's acceptance.
6. Supervising and evaluating both the process sequences of mechatronic systems and facilities and the operational sequence (including quality assurance	He/She can supervise process sequences according to specifi cations as well as implement any requested quality-control measures.	He/She can independently supervise the process sequences, evaluate the results, operate an accompanying statistic process control (SPC) for the quality control plan, and prepare simple work schedules, including production schedule and time management.	He/She can operate and supervise mechatronic facilities, choose testing and monitoring plans, set up the accompanying SPC, seek the optimal results of the production line according to material-flow, and provide work schedules including standard production times.	He/She can master the monitoring of complex mechatronic systems using virtual instruments and PPS systems as well as open loop control for the optimisation of machinery arrangement, material fl ow analysis, and scheduling.	He/She can optimise the process cycles of mechatronic production lines, provide instructions on modifying the PPS systems (e.g. adjustment to SAP systems) and introduce quality systems for continuous improvement processes (CIP/KVP).
7. Installing, configuring, programming and testing hardware and software components for control and regulation of mechatronic systems and facilities	He/She is able to install and configure programs for hardware and software components as well as set up simple software control programs (SPS).	He/She can master the selection of hardware and software for mechatronic systems (sensors, actuators, interfaces, communication procedures) and can provide and test simple software control programs (SPS) according to production process requirements.	He/She can integrate and confi gure program-, control-, and regulation-mechanisms in mechatronic systems, program simple devices (in co-operation with developers), and simulate the program sequence before start-up.	He/She can develop, test, and configure hardware and software solutions for networked mechatronic systems; and can monitor system conditions with suitable measuring and visualisation tools.	
8. Preparing and distributing the technical information for adjustment of each enterprise's mechatronic systems	He/She can provide descriptions and designs of mechatronic subsystems and is familiar with the basic CAD applications.	He/She can fully understand the management of technical information documents for mechatronic systems and can prepare and adapt these documents according to an enterprise's specific operating requirements.	He/She is able to analyse complex operational sequences separately in order to understand the connections and draw up maintenance and production procedures. He/She can understand that the system parameters are important for the equipments' functions and can independently assess and document the wear and general conditions of the mechatronic equipment.		
9. Diagnosing and repairing malfunctions with mechatronic systems and facilities, advising clients on avoiding malfunctions, and modifying and expanding mechatronic systems	He/She can diagnose and repair errors and malfunctions on the simple components and devices in the mechatronic systems. He/She can use the necessary checking, measuring, and diagnostic tools.	He/She can independently correct problems in mechatronic production equipment with the help of (computer- aided) diagnostic systems and the use of expert systems, databases, and error documentations.	He/She can diagnose and repair errors and disturbances in complex mechatronic equipment and is able to advise clients on how to avoid sources of malfunctions through changes or upgrades in the equipment and system.	He/She can diagnose and repair errors and disturbances in complex mechatronic equipment and is able to advise clients on how to avoid sources of malfunctions through changes or upgrades in the equipment and system.	

Allocation in the competence Matrix “Mechanics in industry”

Competence area	Steps of competence development				
1. Maintaining tools, equipment and technical systems	He/she can perform the basic scheduled maintenance on tools and equipment. (e.g. checking the quality of used cooling liquids, checking the oil-level in the milling machine, checking the cutting edges of tools,…).		He/she can master the maintenance procedures for technical systems using service documents and maintenance plans. He/she performs the correct mounting method for machine elements (e.g. shafts, axles, bearings and shaft seals).		He/she understands the function of technical systems, can perform trouble shooting including locating defects and analysing causes for damage. He/she plans, performs and documents necessary maintenance work.
2. Installing and dismantling of assemblies, machinery and systems	He/she can apply written instructions to install and dismantle individual components (e.g. to single parts to an assembly by using machine elements like screw joints or pin connections)		He/she can install/dismantle complex assembly groups and machinery, which could include different technologies. He/she positions and fixes the components by performing detachable and permanent joining processes (e.g. mount bearings to gearboxes, weld frames …).		He/she understands the function of complex machines or systems. He/she can build up a system (consisting of e.g. gear drives, chain drives, belt drives, pneumatic or hydraulic components…). He/she can adjust the associated parameters and analyse/evaluate the overall function of the system.
3. Installing and bringing into service of control technology	He/she can use written instructions to install and adjust pneumatic or hydraulic or electrical components according to safety rules.	He/she can use written instructions to install E-pneumatic or E-hydraulic or electrical components according to safety rules.	He/she can apply an E-pneumatic or E-hydraulic solution for simple tasks.	He/she can apply an E-pneumatic or E-hydraulic solution for complex tasks.	He/she can install and configure programs for hardware and software components as well as set up simple PLCs.
4. Preparing and using technical information	He/she can read and manually draft simple sketches or technical drawings of single components. He/she knows the ISO standards for drafts, surface symbols and dimensioning.		He/she can correctly apply basic CAD functions for the construction of technical components.	He/she can correctly apply advanced CAD-functions for the construction of components and assembly groups. (Including screw joints, pin connections…).	He/she develops technical constructions according to the needs of the customer. He/she can check the functions of complex assembly groups via CAD.
5. Producing single parts and assemblies	He/she can produce simple components by performing manual production tasks, (e.g. filing, sawing, bending…).	He/she can correctly apply conventional machines for the production of components. He/she knows the parameters for calculating cutting speed, feed rate…	He/she can develop the necessary CNCprogram using DIN/ISO programming, and simulate the functionality. He/she can set up the machines and the tools. He/she can produce single parts using CNC machines (e.g. lathes and milling machines), test and optimize production.	He/she can produce parts on CNC machines using CAD/CAM technology up to 3 axes.	He/she can produce parts on CNC machines using CAD/CAM technology in complex settings with more than 3 (4) axes.
6. Working according to QM principals/ standards (documenting, measuring, supervising work	He/she is familiar with methods of testing. He/she can select the necessary test equipment and check it (e.g. micrometre). He/she can work according to inspection plans. He/she can apply inspection equipment correctly.		He/she can develop criteria for functional tests. He/she can prepare inspection plans and documentation. He/she can evaluate inspection results and identify the cause of quality problems.	He/she can develop inspection plans based on QM regulations (also in respect of mass and serial production). He/she is familiar with tools/methods to support continuous improvement processes in order to optimize the production process.	He/she can control product and process quality. He/she can carry out inspection of machine and process capability on demand. He/she can plan the process as well as document and evaluate process data. He/she can make suggestions for optimizing the quality of process.
7. Planning, carrying out and optimising technical systems	He/she can plan production processes for typical single parts. He/she can perform and optimize these processes.	He/she can plan production and mounting processes for typical assemblies. He/she can perform and optimize these processes.	He/she can provide independent technical solutions for the construction e.g. of production lines. He/she can assure the functionality of the overall system by using existing and modified standard components. He/she can check failure-free working systems and production processes concerning their potential for optimization. He/she can work out suggestions for optimization regarding technical development. He/she can evaluate and estimate the economic advantage. He/she can carry out the proposal.		

Content learning outcome

Learning Outcomes After completing this work order the student is able to…		Taxonomy Table
1. Safety precautions		
SP 1	name and memorize (1F) the safety precautions and work instructions.	1F
SP 2	formulate (5Ca) further safety precautions.	5Ca
SP 3	identify (4Ca) hazardous situations	4Ca
2. Production of compressed air		
CA 1	tabulate and describe (1F) the components.	1F
CA 2	summarize (2Ca) the production of compressed air	2Ca
CA 3	understand (2F) the flow diagram.	2F
CA 4	describe (2Ca) the valve settings.	2Ca
3. Work orders		
3.1 Pneumatic Basics WO 1		
WO 1.1	develop (3F) electro - pneumatic circuits by means of standard components.	3F
WO 1.2	differentiate (2F) single and double acting cylinder, standard way valves, direct and indirect control of cylinders.	2F
WO 1.3	use (3F) the item designation systematically.	3F
3.2 Sliding door WO 2		
WO 2.1	describe (1F) the function of the magnetic proximity sensor.	1F
WO 2.2	differentiate (2C) between AND and OR logic operations.	2Ca
WO 2.3	analyse (4P) the result of the loss of air for your circuit.	4P
WO 2.4	carry out (3P) the development and simulation of the circuit for the task.	3P
WO 2.5	check and evaluate (5Ca, 5P) your circuit.	5Ca, 5P

3.3 roller conveyor WO 3		
WO 3.1	carry out (3P) the correct connection of a proximity sensor in an electric circuit.	3P
WO 3.2	understand (2F) the function of the different proximity sensors	2F
WO 3.3	recognize (1F) and apply (3P) the appropriate proximity sensor for the task.	1F, 3P
WO 3.4	carry out (3P) the development and simulation of the circuit for the task.	3P
WO 3.5	check and evaluate (5Ca, 5P) your circuit.	5Ca, 5P
3.4 Vaccum WO 4		
WO 4.1	describe (1F) the function and principle of the vacuum generator.	1F
WO 4.2	describe (1F) the function of a pneumatic semi rotary drive.	1F
WO 4.3	analyse (4P) the result of the loss of electric power for your circuit.	4P
WO 4.4	carry out (3P) the development and simulation of the circuit for the task.	3P
WO 4.5	check and evaluate (5Ca, 5P) your circuit.	5Ca, 5P
3.5 Sawing fixture WO 5		
WO 5.1	describe (1F) the function of the pressure switch.	1F
WO 5.2	calculate and select (3Ca) the appropriate cylinder.	3Ca
WO 5.3	calculate and analyze (4Ca) the air consumption.	4Ca
WO 5.4	carry out (3P) the development and simulation of the circuit for the task.	3P
WO 5.5	check and evaluate (5Ca, 5P) your circuit.	5Ca, 5P
3.6 Stamping device WO 6		
WO 6.1	use (3Ca) the correct item designation.	3Ca
WO 6.2	choose (3Ca; 3P) a suitable proximity sensor	3Ca, 3P
WO 6.3	understand (2Ca) and develop (3P) a sequence chain.	2Ca, 3P
WO 6.4	carry out (3P) the development and simulation of the circuit for the task.	3P
WO 6.5	check and evaluate (5Ca, 5P) your circuit.	5Ca, 5P

5. Test		
Test 1	describe (1F) the function of the magnetic proximity sensor.	1F
Test 2	understand (2F) the funktion of the different proximity sensors.	2F
Test 3	understand (2F) the difference between a 5/2-way single solenoid valve and a 5/2-way double solenoid valve.	2F
Test 4	describe (1F) the function and principle of the vacuum generator.	1F
Test 5	calculate and select (3Ca) the appropriate cylinder	3Ca
Test 6	calculate and analyze (4Ca) the air consumption	4Ca
Test 7	argue (5Ca) economical aspects	5Ca

Taxonomy Table

		Cognitive Process					
		Remember (1)	**Understand (2)**	**Apply (3)**	**Analyze (4)**	**Evaluate (5)**	**Create (6)**
Knowledge	**Factual knowledge (F)**	SP 1 CA 1 WO 2.1 WO 3.3 WO 4.1 WO 4.2 WO 5.1 Test 1 Test 4	CA 3 WO 1.2 WO 3.2 Test 2 Test 3	WO 1.1 WO 1.3			
	Casual knowledge (Ca)		CA 2 CA 4 WO 2.2 WO 6.3	WO 5.2 WO 6.1 WO 6.2 Test 5	SP 3 WO 2.3 WO 5 Test 6	SP 2 WO 2.5 WO 3.5 WO 4.5 WO 5.5 WO 6.5 Test 7	
	Procedural knowledge (P)			WO 2.4 WO 3.1 WO3.3 WO 3.4 WO 4.4 WO 5.3 WO5.4 WO 6.2 WO 6.4	WO 2 WO 4.3	WO 2.5 WO 3.5 WO 4.5 WO 5.5 WO 6.5	

SP= safety precautions

CA= compressed air

Timetable for the Module

average school day:

08.00 – 09.30	lessons	Room 05
09.30 - 09.45	morning break	
09.45 - 12.30	lessons	Room 05
13.30 - 15.30 or longer	Study, company visit, museum…	

school		
when	what	where
Su. 15.01.12	Students arrive in Munich	hostel
Mo. 16.01.12	08.30 meet and greet Organisation: tickets, meals, schedule,… Evaluation: questionnaire 13.30-15.30 City rally	room 208
Tu. 17.01.12	08.00 lessons: Fischer, Schott 13.30 study	Room 05
We. 18.01.12	08.00 lessons: Fischer, Schott 13.30 study	Room 05
13:30	company visit, (Nachtigall, Volksheimer) SWM in Fröttmaning Olympia swimming hall, Fischer	SWM: Techn. Basis Nord
Th. 19.01.12	08.00 lessons: Schott, Schauhuber, 13.30 Dt. Museum Philipp Schott	Room 05 Dt. Museum
Fr. 20.01.12 13.30	08.00 lessons: Schott, Schauhuber, paper and pencil test sports Stengel test results	Room 05
Sa. 21.01.12 Su. 22.01.12	Sightseeing Munich (Kneidl, Matzek) Häfner mit Azubis Weekend 1	

Company: BMW, Seidenader, SWM **Example SWM**		
Mo. 23.01.2012 Team work: mixed nation teams	Welcome, organisation, tour Instruction at the workstation: relay, valve, cable end sleeve, terminal block,… safety rules Getting started: written order that contains the task: “Abschlussprüfung 1/ 2011, Industriemechaniker” Team work: mixed nation teams	BMW Seidenader SWM/VET
Tu. 24.01.2012 Team work: mixed nation teams	“Abschlussprüfung 1/ 2011, Industriemechaniker” Troubleshooting and optimisation if necessary Appraisal of results (IHK-Auswertbogen) “Test”: Expert discussion (without grading) Team work: mixed nation teams	BMW Seidenader SWM/VET
We. 25.01.2012	Work at the company/ Subway maintenance Maintenance of electropneumatic components Demounting, repairing, mounting, testing, documentation Team work: mixed nation teams	SWM:Techn. Basis Nord
Th. 26.01.2012	Work at the company/ Subway maintenance Maintenance of electropneumatic components Demounting, repairing, mounting, testing, Team-presentation (10 slides as result for certificates celebration) Team work: mixed nation teams (Meeting trainers and teachers skills demo: 14 h BSFT)	SWM:Techn. Basis Nord
Fr. 27.01.2012	Kick off Handling module: Written work order, documentation of the components, safety instructions; Difficulty: At least 3 cylinders/ actors	BMW Seidenader SWM/VET
Afternoon 13-15.00h	Prepare team-presentation (app. 10 slides or 5 minutes as result for certificates celebration)	
Sa. 28.01.12 Su. 29.01.12	Weekend 2: sledging or Andechs (Matzek, Kneidl) with Hr. Fischer	

Mo. 30.01.2012	Handling module: Team work: mixed nation teams	BMW Seidenader SWM/VET
	13.30 company visit, Seidenader (Fessler, Neumeier, Hanslmayer)	
Tu. 31.01.2012	Handling module: Team work: mixed nation teams	
We. 01.02.2012	Handling module: Team work: mixed nation teams	
	13.30 –15.30 company visit, BMW (Kneidl, Matzek)	
Th. 02.02.2012 8.00h	Skills demonstration/ expert talk	BMW Seidenader SWM/VET
13:30 p.m.	**Evaluation TUM**	BSFT 208
Fr. 03.02.2012 Morning Celebration with partners	**Certificates: given by companies** Speeches, Presentations: students, BSFT, companies, TUM… Farewell Common lunch	BSFT Aula Room 320

average company day: example SWM

07.00	Meeting, than work	
09.00-09.15	morning break	
12.00-12.45	Lunch break	
15.30	Leisure time	

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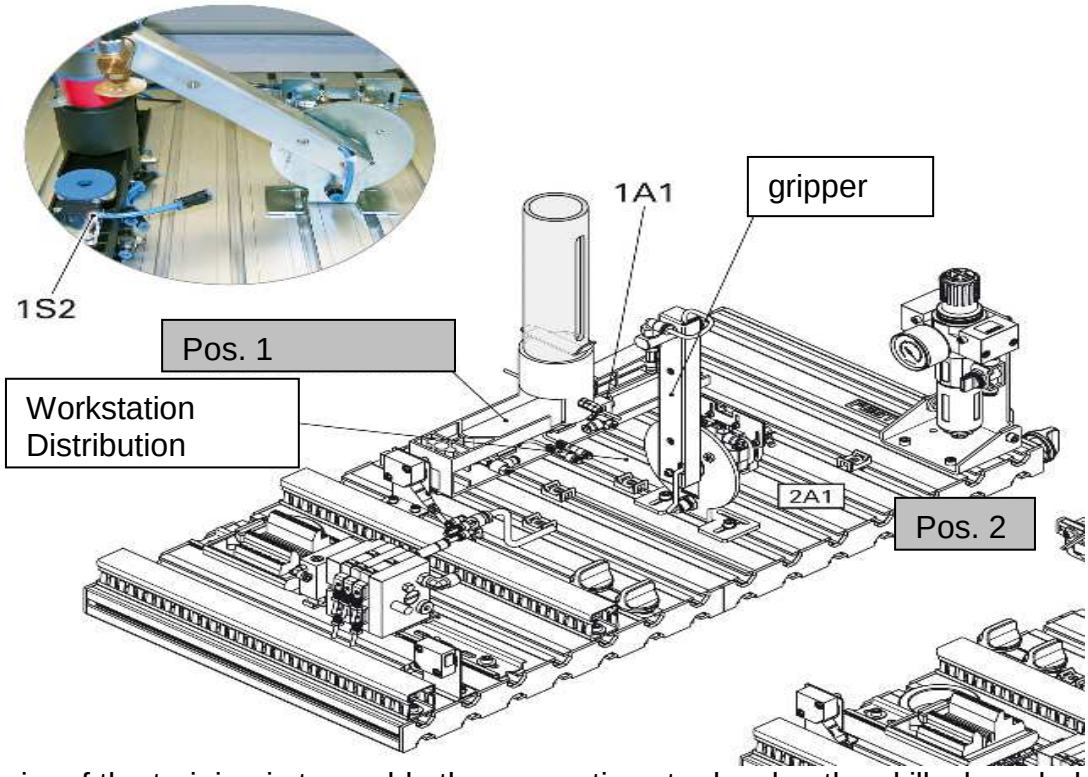
Module Electro-Pneumatics

Learning Material for Students



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Instruction Sheet

The electro-pneumatics module has the following structure:

Unit	Content
Unit 1	**Safety**: you will learn how to work safely with the electro-pneumatic equipment.
Unit 2	**Production of compressed air**: you will learn how compressed air is produced.
Unit 3	**Work orders 1-6**: you will learn how to solve problems in automation technology using electro-pneumatics. Every work order consists of a part that contains the tasks and information you might need to help you solving the problems.
Unit 4	**Glossary**: here you find the necessary technical terms in your language

In every work order you will proceed through the following steps:

- **Information**: Study your work order also using the provided information material.
- **Planning**: Plan, develop and simulate with FluidSIM.
- **Realisation**: Realise your solution on the profile plate with electro-pneumatic components.
- **Checking**: Check your own work using your evaluation sheet.
- **Evaluation**: Evaluate your work together with your teacher using your evaluation sheet.

Evaluation work orders

Every work order is going to be evaluated in two steps.
(There is a maximum of 5 points for the tasks, 10 points for the circuit diagram and 15 for the function)
Self check:
First you check if all the tasks, the circuit diagram and the necessary functions of the work order are completed. Then you fill in the points you would give yourself.
Evaluation:
Then you are going through the same process with your teacher and see how she/he evaluates your work. All together you can get a maximum of 30 points for every work order.

Work orders		**Tasks 5P**	**Circuit Diagram 10P**	**Function 15P**	**Result**
WO 1	Self check				
	Evaluation				
WO 2	Self check				
	Evaluation				
WO 3	Self check				
	Evaluation				
WO 4	Self check				
	Evaluation				
WO 5	Self check				
	Evaluation				
WO 6	Self check				
	Evaluation				

Result	points	
	mark	

points	180-151	150-121	120-91	90-46	45-0
mark	**1**	**2**	**3**	**4**	**5**

1. Safety Precautions and work instructions

Learning outcomes:

After completing this work order:

You´ll be able to name and memorize (1F) the safety precautions and work instructions.

You´ll be able to identify (4Ca) hazardous situations

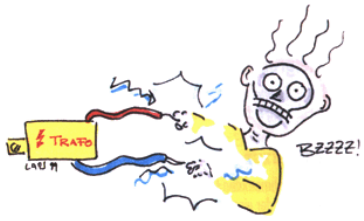
You´ll be able to formulate (5Ca) further safety precautions.

Task:

1. Identify hazardous situations in your working environment.
2. Formulate further safety precautions and write them on the sheet.

Electrical:

- work only in the absence of voltage
- use low voltage only (24V vs. 230V)



Mechanical:

- mount all components securely
- hands off the limit switches, push it only using a tool (e.g. screwdriver)
- hands off the moving parts

Pneumatics:

- danger when tubings slipping off
    - use short tubing connections
    - switch compressed air off immediately if tubing slips off
- push the tubing into the push-in connector as far as it will go
- the tubing can be pulled out, after pressing down the blue release ring
- don´t disconnect tubing while under pressure
- complete and secure all the tubing connections before switching on the compressed air
- attention: while switching compressed air on, cylinders may activate automatically

_____

_____

_____

_____

_____

General:

_____

_____

_____

_____

_____

2. Production of compressed air

Learning outcomes:

After completing this work order:

You'll be able to tabulate and describe (1F) the components.

You'll be able to understand (2F) the flow diagram.

You'll be able to describe (2Ca) the valve settings.

You'll be able to summarize (2Ca) the production of compressed air

The following four components are important for producing compressed air:

- screw compressor
- filters
- oil-water separator
- absorption air dryer

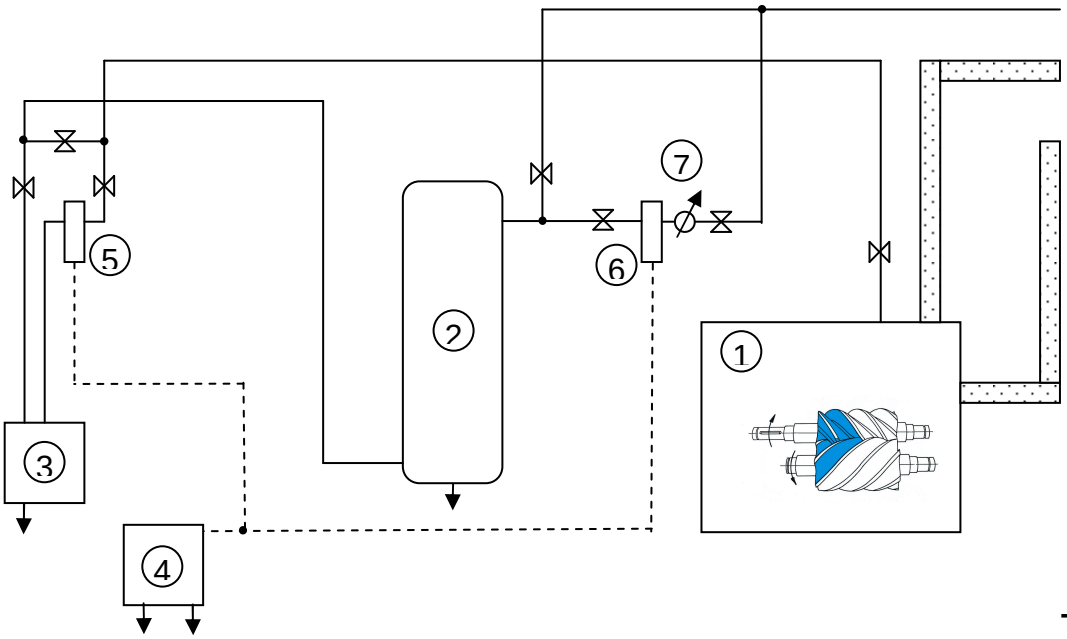
Form four different international teams and choose one of the components (best: one of each country) and do the following task:

Read through the Information of the chosen component and prepare a short spoken presentation/ speech (2-5 minutes) for the others.

The following aspects can be interesting:

- name of the component
- function of the component
- explain important vocabulary
- things of interest

Afterwards we are going to visit the place were the compressed air is produced in BSFT and each group identify and explain its part of the system.



Tasks:

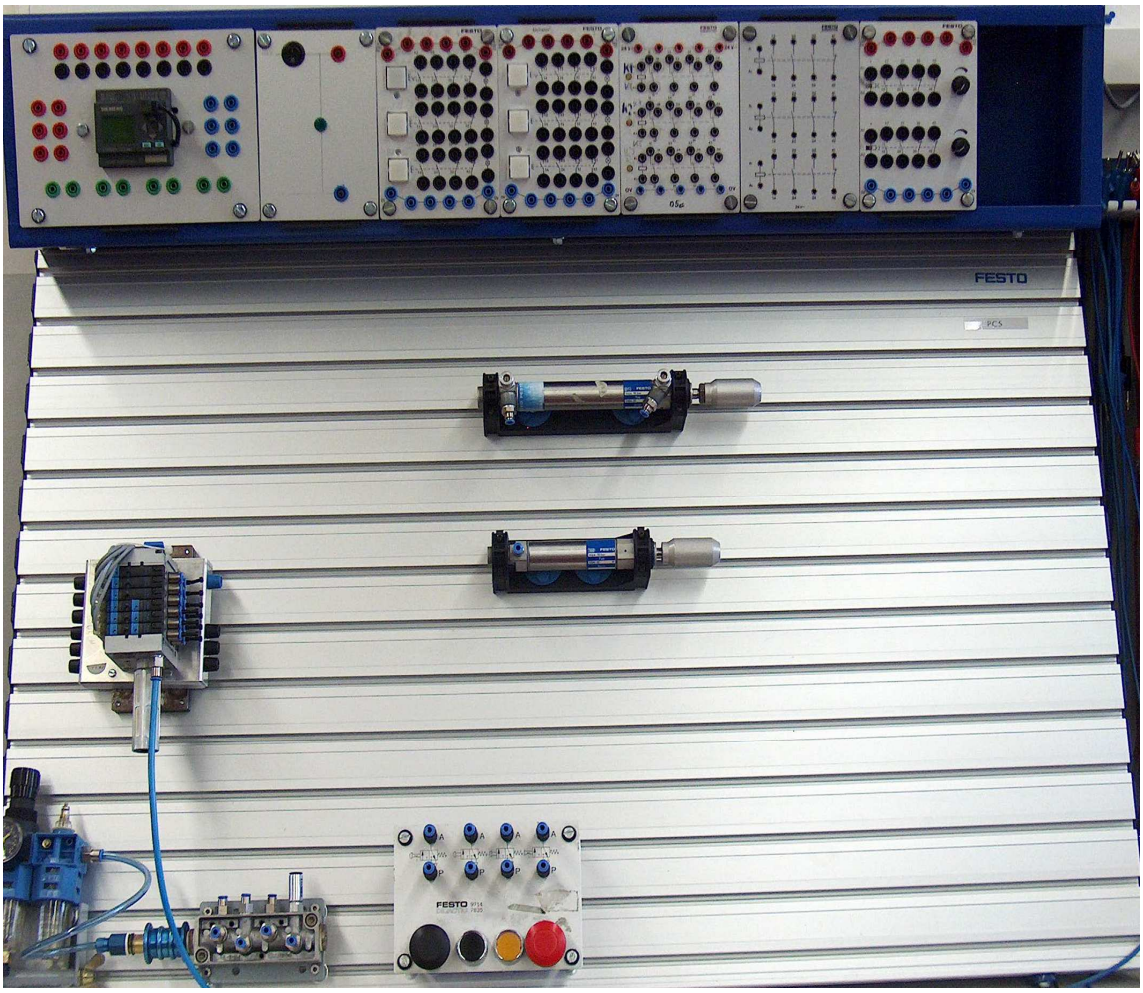
1. Fill in the components rightly in the table below

refrigerated air dryer / compressed air filter / compressed air reservoir / oil water seperator / compressed air filter / pressure regulator / compressor /

1.	
2.	
3.	
4.	
5.	
6.	
7.	

2. Mark the lines in the diagram with the right colours:
   - warm compressed air: red
   - prepared air: blue
   - incoming air: green
   - exhaust air: orange
   - condensate line: yellow
3. Mark the closed valves ⋈ red and the open valves blue for normal operation
4. Describe in your own words the 4 steps from ambient air to cooled, clean compressed air. Use the colours from the diagram above.

3. Work orders



3.1 Pneumatic basics (WO1)

Learning outcomes

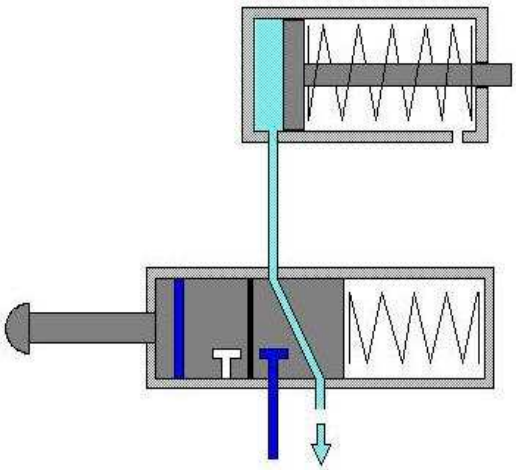
After completing this work order:

You'll be able to develop (3F) electro - pneumatic circuits by means of standard components.

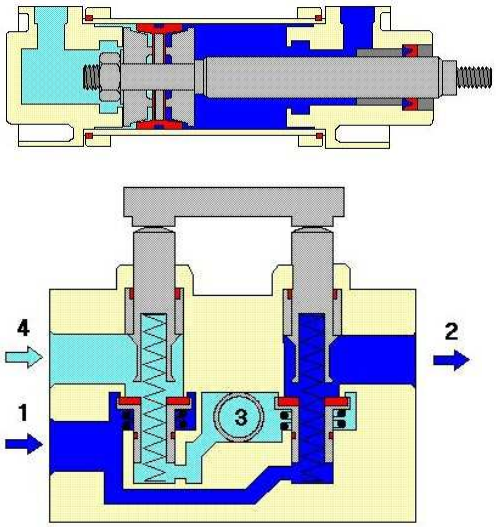
You'll be able to differentiate (2F) single and double acting cylinder, standard way valves, direct and indirect control of cylinders.

You'll be able to use (3F) the item designation systematically.

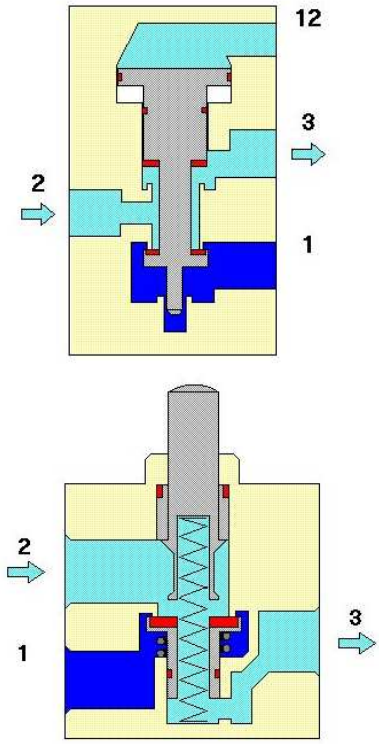
Pneumatic basic controls

function	pneumatic circuit
1.1 Direct control of a single acting cylinder	
	

1.2 Direct control of a double acting cylinder

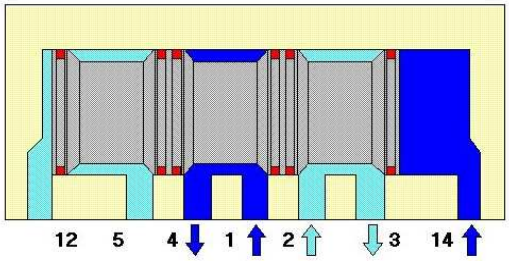


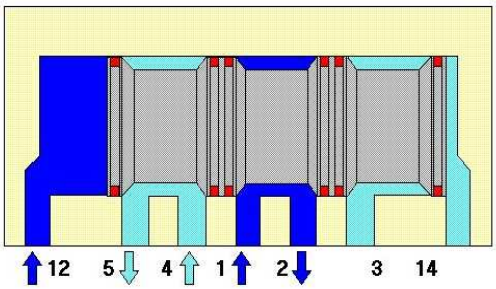
1.3 Indirect control of a single acting cylinder via a monostable 3/2 way valve



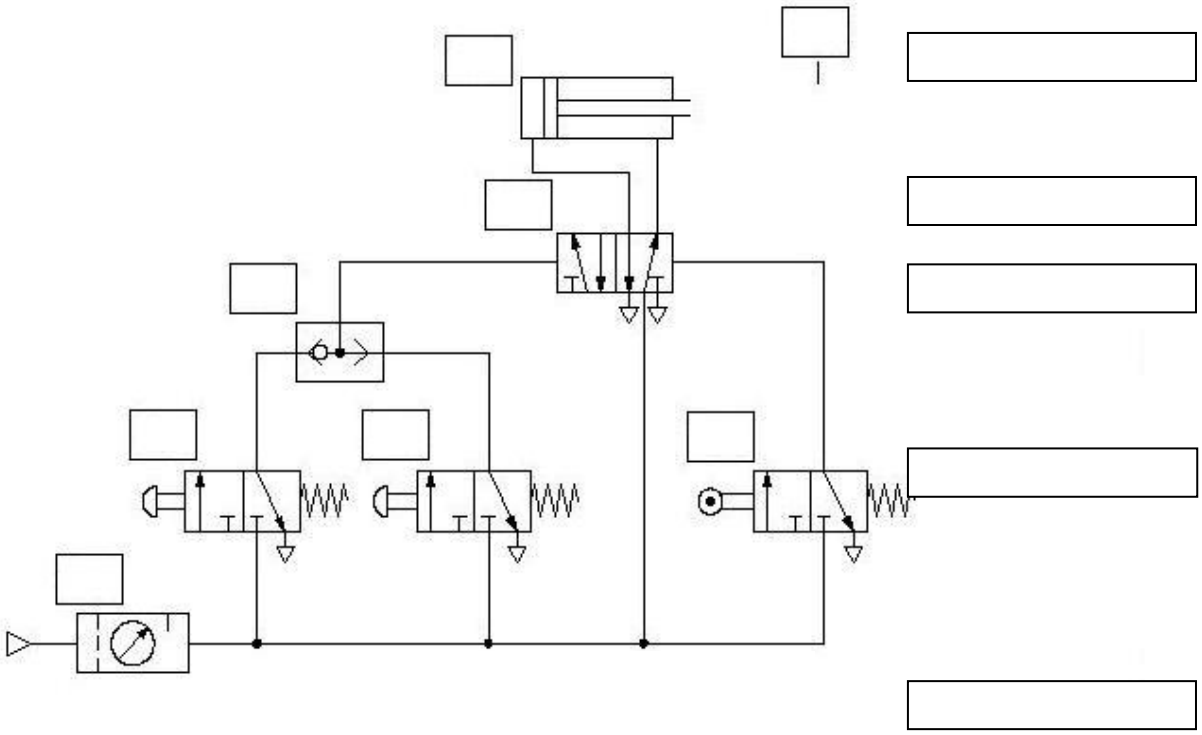
1.4 Indirect control of a double acting cylinder via a monostable 5/2 way valve

1.5 Indirect control of a double acting cylinder by means of a 5/2-way valve, pneumatically actuated at both ends





Item	designation
	drives
	signal
	proximity sensor
	valves
	all other parts



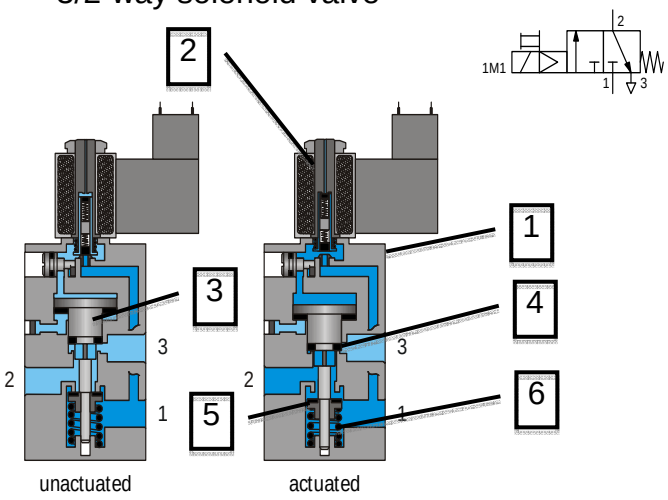
Designations for connections

Pneumatics	*Connection*	*Older pneumatics or hydraulics*
	inflow, pessure port	
	working port	
	exhaust port, tank	
	control port	

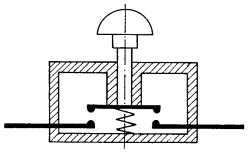
Electro-pneumatic basic controls

2.1 Direct control of a single acting cylinder

3/2-way solenoid valve



Pushbutton, normally open contacts

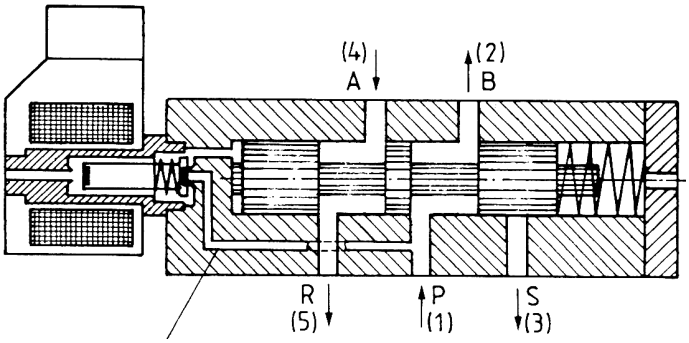


Name the parts of the solenoid valve

1	
2	coil
3	pistol
4	
5	
6	spring

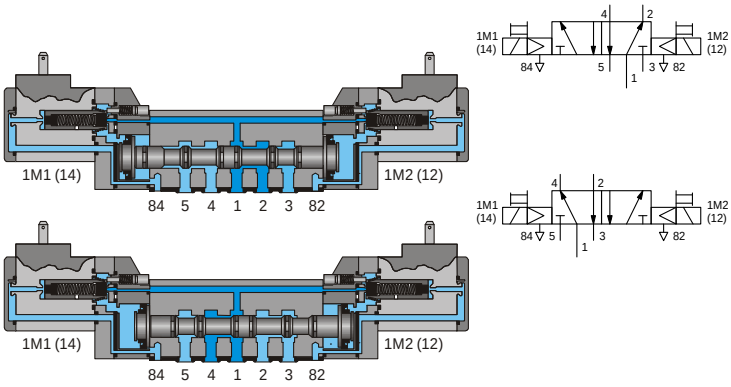
Fill in the numbers of the contacts
for the pushbutton normally open (n. o.).

2.2 Direct control of a double acting cylinder



Describe the valve:

2.3 Direct control of a double acting cylinder by means of a 5/2-way double solenoid valve



3.2 Sliding door (WO2)

Learning outcomes

After completing this work order:

You'll be able to describe (1F) the function of the magnetic proximity sensor.

You'll be able to differentiate (2Ca) between AND and OR logic operations.

You'll be able to analyse (4Ca, 4P) the result of the loss of air for your circuit.

You'll be able to carry out (3P) the development and simulation of the circuit for the task.

You'll be able to check and evaluate (5Ca, 5P) your circuit.

Presentation of the problem

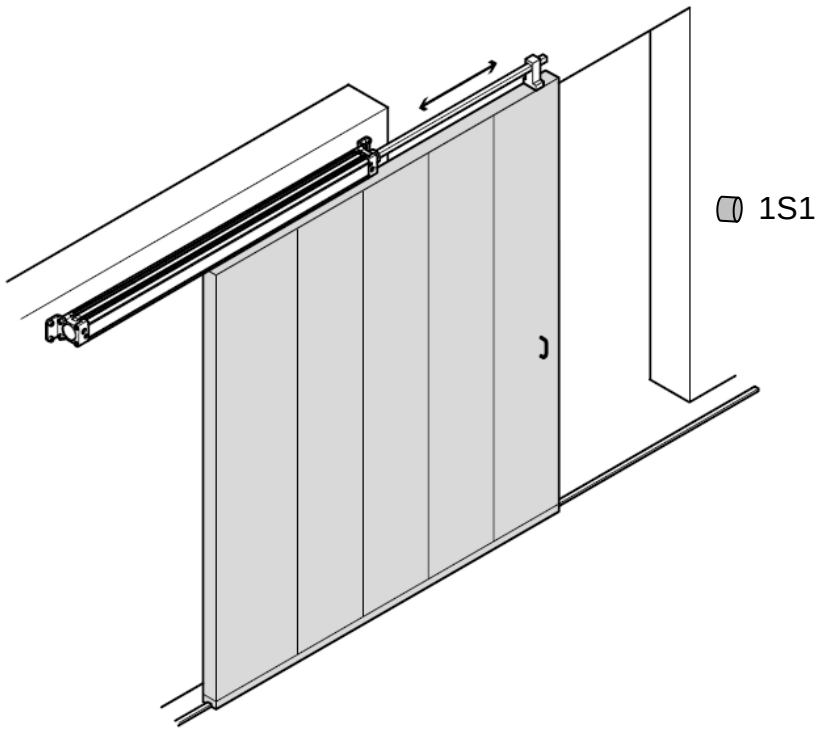
A sliding door between two rooms needs to be opened and closed by using a pushbutton. Only one pushbutton should be located at each side of the door (1S1, 1S2) in order to prevent operator error in case of an emergency.
The process can only be started when the door is in one of its end positions. The Pressure must be limited to 3 bar (300 kPa) for safety reasons (danger of pinching).

Procedure

When the sliding door is in one of its defined end positions, it can be moved to the other end position by pressing the pushbutton. The door can thus be opened and closed.

The opening and closing processes cannot be started as long as the door is not in one of its end positions.

Layout



Tasks

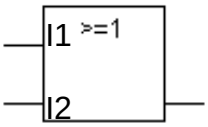
1. Create and simulate the electro-pneumatic circuit diagram for the sliding door's control system with correct description of the components including an equipment list.
2. Set up the control system on your mounting plate.

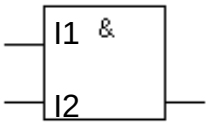
Reed switch

3. Describe the function of the magnetic proximity sensor 540695. What type of cylinder is therefore needed? For function presentation see: http://reed-switch-info.com/

Additional tasks

4. What happens if compressed air supply fails during advance or return motion?
5. How can the control system be put back into operation, what must be done?
6. Fill in the function/truth table below.

>=1 : OR Logic Operation	Function/truth table	Description of function
	I1 | I2 | Q 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |	

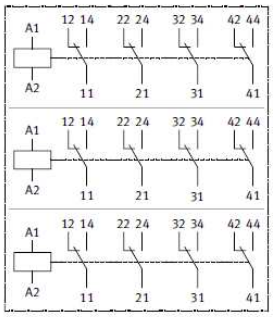
& : AND Logic Operation	Function/truth table	Description of function
	I1 | I2 | Q 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |	

Relays

Tasks

Test the relay:

1. Connect a n.o. contact S1 with A1 and A2 of the relay coil (K1)
   Connect a lamp P1 that lights if you operate S1.
   Connect a lamp P2 that goes off if you operate S1.



2. Create and simulate the circuit diagram.
3. Set up the circuit diagram on your mounting plate.
4. Describe the functions of relays in electric circuits.

3.3 Roller conveyor (WO3)

Learning outcomes

After completing this work order:

You'll be able to carry out (3P) the correct connection of a proximity sensor in an electric circuit.

You'll be able to understand (2F) the function of the different proximity sensors.

You'll be able to recognize (1F) and apply (3P) the appropriate proximity sensor for the task.

You'll be able to understand (2F) the difference between a 5/2-way single solenoid valve and a 5/2-way double solenoid valve.

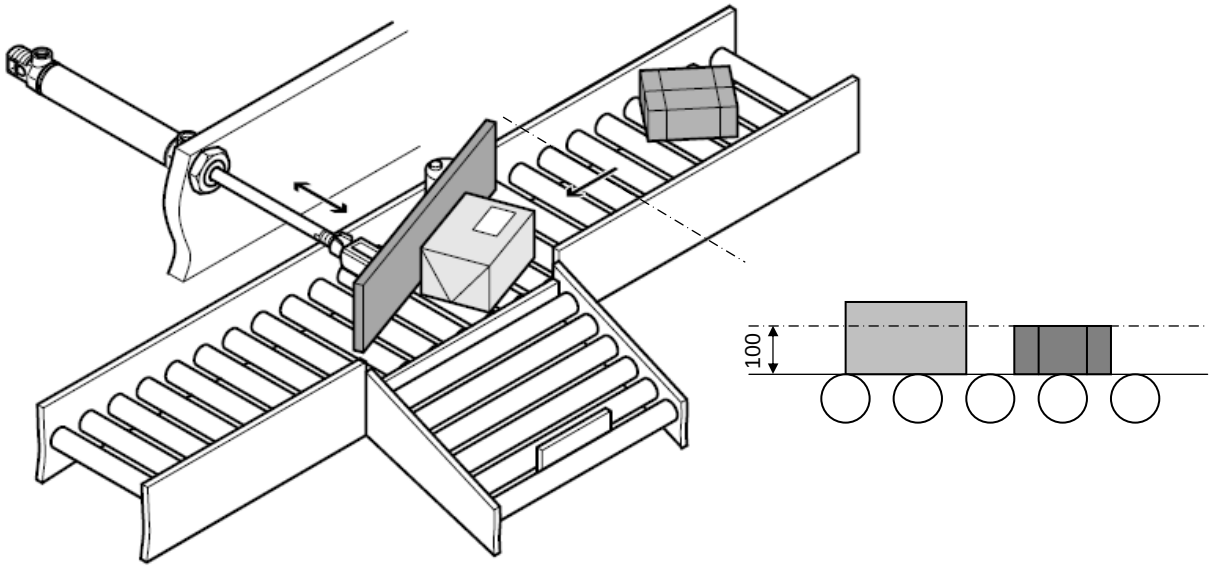
You'll be able to carry out (3P) the development and simulation of the circuit for the task.

You'll be able to check and evaluate (5Ca, 5P) your circuit.

Presentation of the Problem

The roller conveyor transports packages of different heights. If a package is higher than 100mm it should be pushed off the roller conveyor.

Layout



Procedure

If a proximity sensor detects a "high" package and the on-switch is activated the double acting cylinder extends and after having pushed the package off, retracts automatically.

Choose an appropriate proximity sensor. Use a 5/2-way single solenoid valve and a double acting cylinder for the control system.

Tasks

1. Do the information part **proximity sensors** of WO 3.
2. Describe the difference between an inductive and a magnetic proximity sensor!
3. Create and simulate the electro-pneumatic circuit diagram for the roller conveyor control system with correct description of the components including an equipment list.
4. Set up the control system on your mounting plate.
5. Describe the difference in function between a 5/2-way **single** solenoid valve and a 5/2-way **double** solenoid valve.

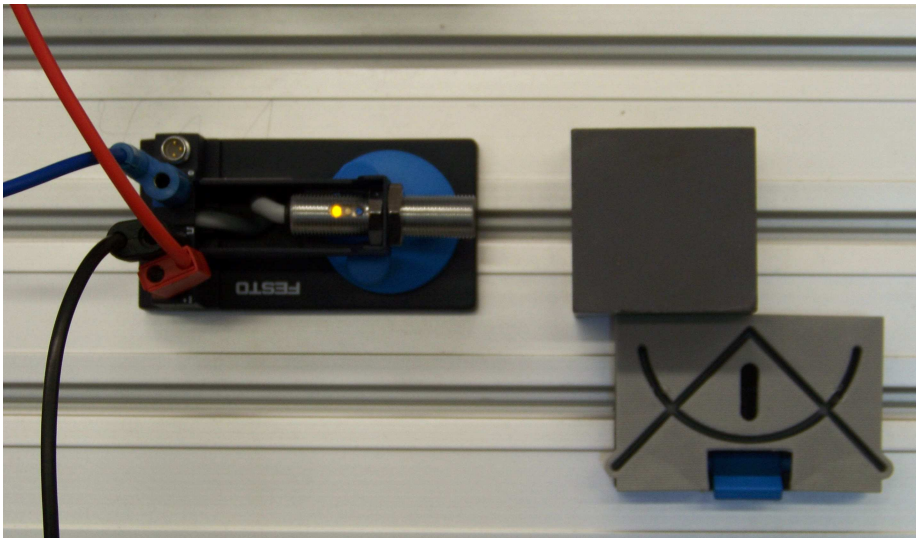
Proximity sensors

In order to find out how different proximity sensors react to different materials do the following tests.

Equipment

Objects: cubes made of aluminium, grey plastic, transparent plastic

Proximity sensors: inductive, capacitive, optical (see Book of Tables)



Tasks

1. Create and simulate the electric circuit diagram for the proximity sensors.
2. Set up the circuits on your mounting plate.

Connect the sensor to a 24 V DC power supply and the output Q1 to a signal lamp P1

3. Test the 3 proximity switches and fill in the table
   (1 = sensor reacts to material; 0 = sensor does not react).

proximity sensor	symbol	material			
		aluminium	black plastic	white plastic	steel
inductive					
optical					
capacitive					

3.4 Vacuum (WO4)

Learning outcomes

After completing this work order:

You'll be able to describe (1F) the function and principle of the vacuum generator.

You'll be able to describe (1F) the function of a pneumatic semi rotary drive.

You'll be able to analyse (4P) the result of the loss of electric power for your circuit.

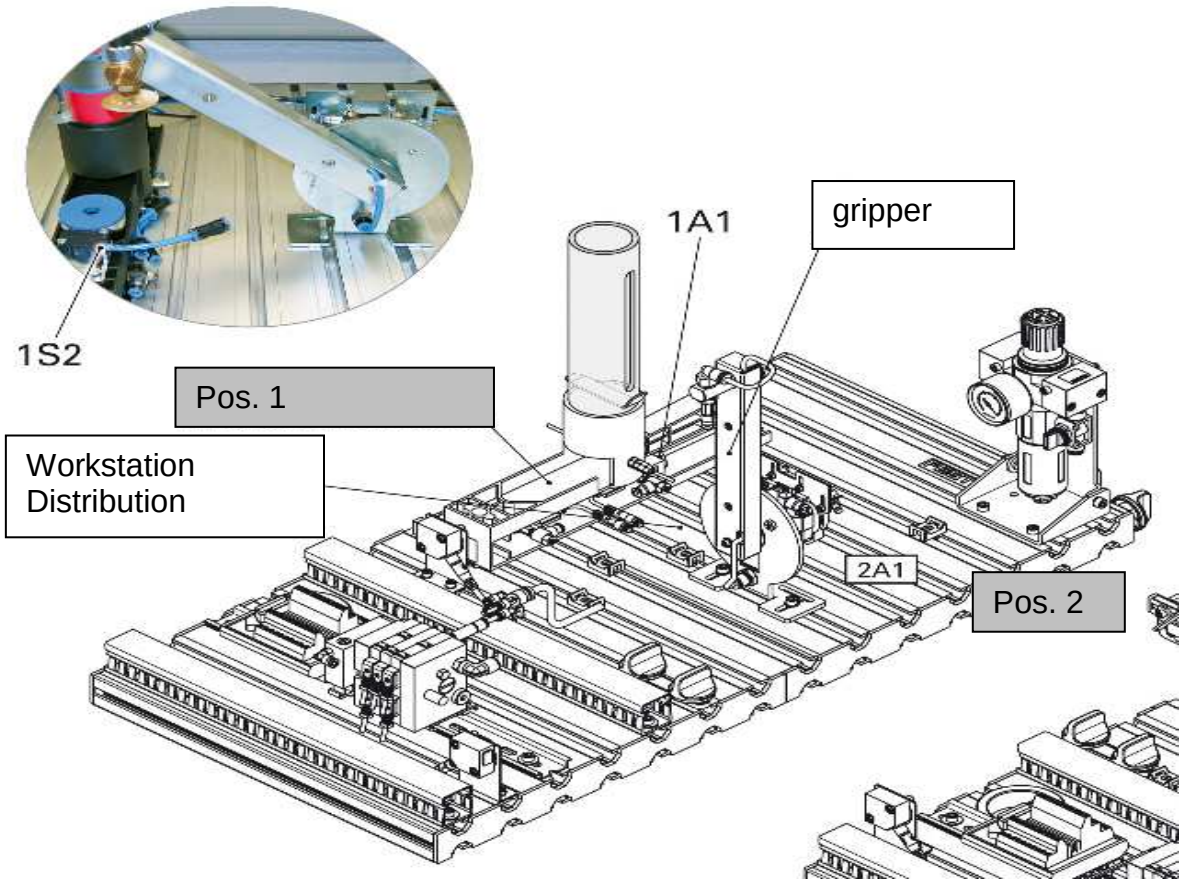
You'll be able to carry out (3P) the development and simulation of the circuit for the task.

You'll be able to check and evaluate (5Ca, 5P) your circuit.

Presentation of the problem

Workpieces shall be transported from the distribution workstation to the next one. A gripper transports the workpiece from position 1 to the next station position 2. The gripper consists of a vacuum generator/suction cup and a pneumatic semi rotary drive.

Layout



Procedure

The gripper moves from position 2 to position 1.

When the gripper is in position 1 and the suction cup holds the workpiece safely by means of a vacuum the semi rotary drive moves back to position 2 and drops the workpiece.

The process is started if the capacitive proximity sensor in Pos. 1 detects the plastic workpiece and the on-switch is operated.

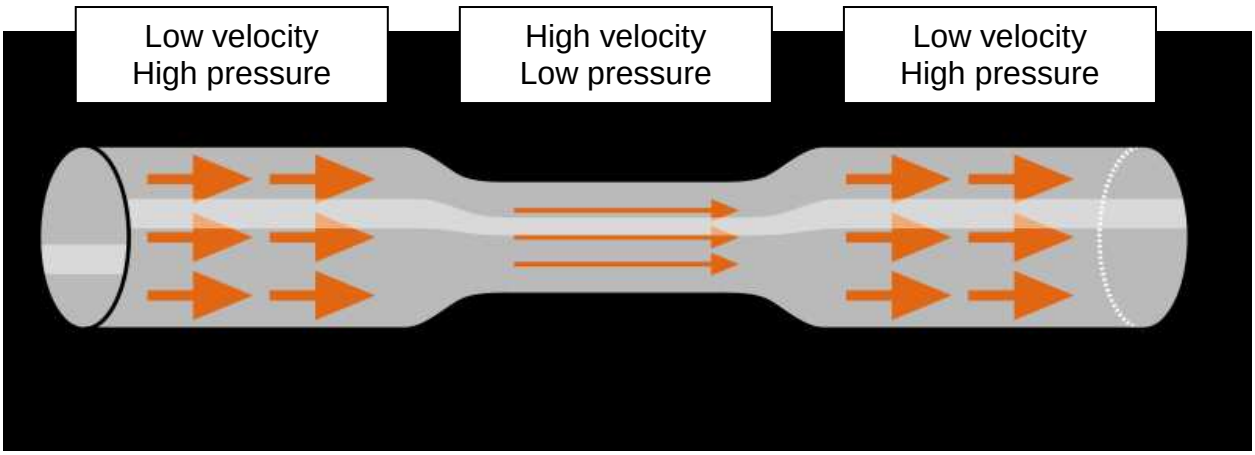
Tasks

1. Check http://youtu.be/zkM9Ir30rw8 to see an example for handling with vacuum.
2. Create and simulate the electro-pneumatic circuit diagram for the vacuum work order with correct description of the components including an equipment list.
3. Set up the control system on your mounting plate.
4. Describe the function of the vacuum generator/suction cup 152891. Find another example which uses the same principle. Check also http://youtu.be/8MvHplOIQCI.
5. Describe the function of a pneumatic semi rotary drive.
6. What happens in the case of an electric power loss during the transport of the work piece?

Venturi effect

The **velocity** of the air increases as the cross sectional area decreases.

The **pressure** of the air decreases as the cross sectional area increases.



Venturi effect

In which area of the pipe would you connect the suction cup?

3.5 Sawing fixture (WO5)

Learning outcomes:

After completing this work order:

You'll be able to describe (1F) the function of the pressure switch.

You'll be able to calculate and select (3Ca) the appropriate cylinder.

You'll be able to calculate and analyze (4Ca) the air consumption.

You'll be able to carry out (3P) the development and simulation of the circuit for the task.

You'll be able to check and evaluate (5Ca, 5P) your circuit.

Presentation of the problem

A wooden board is clamped by means of a single-acting cylinder. The cutting feed with the saw is done by means of a double acting cylinder.

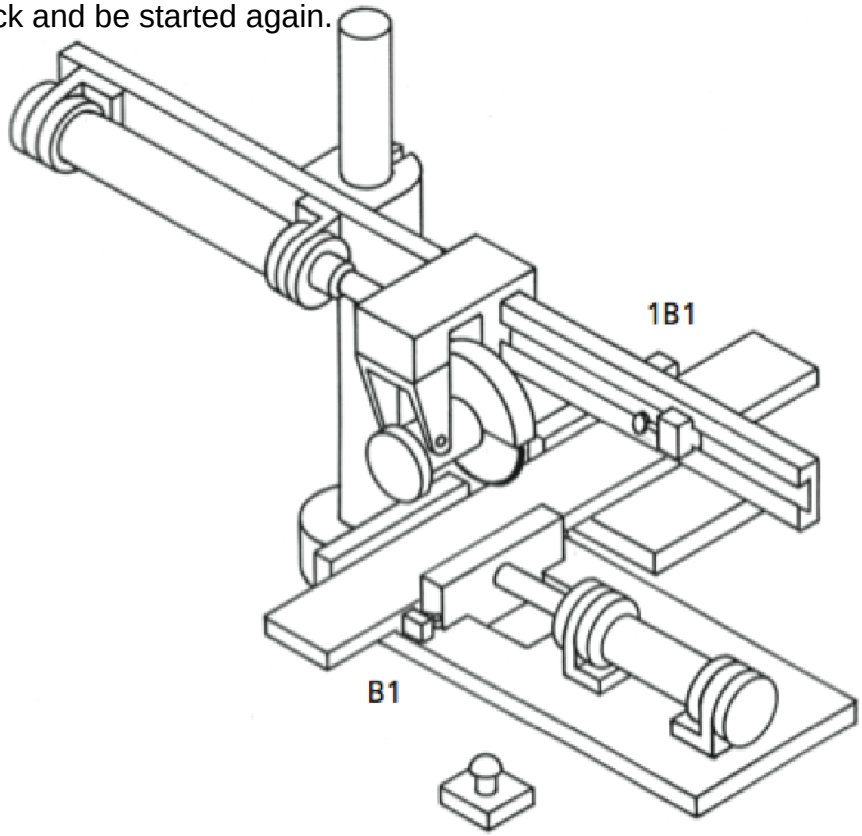
Procedure

First the componentes should be clamped manually by a single-acting cylinder.

The double-acting cylinder can only extend after reaching a pressure of 4.5 bar at the single acting cylinder and by pushing the two handbuttons. (Note: not a two-hand safety control)

If the pressure decreases the cylinder must retract. After reaching the end position the saw has to go back and be started again.

Layout:



Calculation for the sawing fixture:

The single-acting cylinder needs a force of **1000 N** by an operation pressure of **6 bar**. The stroke length is **50 mm**.

The efficiency is **88 %**.

The double-acting cylinder needs a force of **700 N** by an operation pressure of **6 bar**. The stroke length is **300 mm**.

The efficiency is **93 %**.

1. Chose the right cylinders with the Festo datasheet. Check the result with a calculation!
   (Result single-acting: 50mm; double acting: 40mm)
2. Calculate the air consumption of the double-acting cylinder if it works 6 times per minute forward and backward. (Result: 31.7 l/min)
3. How much more air is consumed if you use a 50 mm double-acting cylinder instead of a 40 mm.
   (Result: 49.7 l/min)
4. Calculate the difference in costs for one hour of operating. (1m³ compressed air costs 0.025 €)
   (Result: 40mm => 0.0475 €/h; 50mm => 0.0725 €/h)

Task:

1. Create and simulate the electro-pneumatic circuit diagram for the sawing fixture with correct description of the components including an equipment list.
2. Build the construction according to your Documents and test the function.
3. Describe the function of the pressure switch.

Important settings of the SMC pressure switch

F0	**choose pressure unit**		
	push (long)	S	
	adjust **F0** with	△ ▽	
	confirm with	S	
	adjust unit **bar** with	△ ▽	
	confirm (long) with	S	
P1	**adjust switching pressure**		
	push (short)	S	**P1** appears
	adjust pressure with	△ ▽	
	confirm with	S	
F1	**adjust vacuum**		
	push (long)	S	
	adjust **F1** with	△ ▽	
	confirm with	S	**HYS** appears
	confirm with	S	**1_P** appears
	confirm with	S	
	adjust pressure with	△	e.g. - 0,3 bar
	confirm (long) with	S	
F99	normal position (reset)		
	push (long)	S	
	adjust F99 with	△ ▽	
	confirm with	S	
	adjust "on" with	△ ▽	
	push	S + ▽	for 5s => F99 appears
	confirm (long) with	S	
	Note: The pressure unit must be adjusted again!		

3.6 Stamping device (WO6)

Learning outcomes:

After completing this work order:

You'll be able to use (3Ca) the correct item designation.

You'll be able to choose (3Ca; 3P) a suitable proximity sensor

You'll be able to understand (2Ca) and develop (3P) a sequence chain.

You'll be able to carry out (3P) the development and simulation of the circuit for the task.

You'll be able to check and evaluate (5Ca, 5P) your circuit.

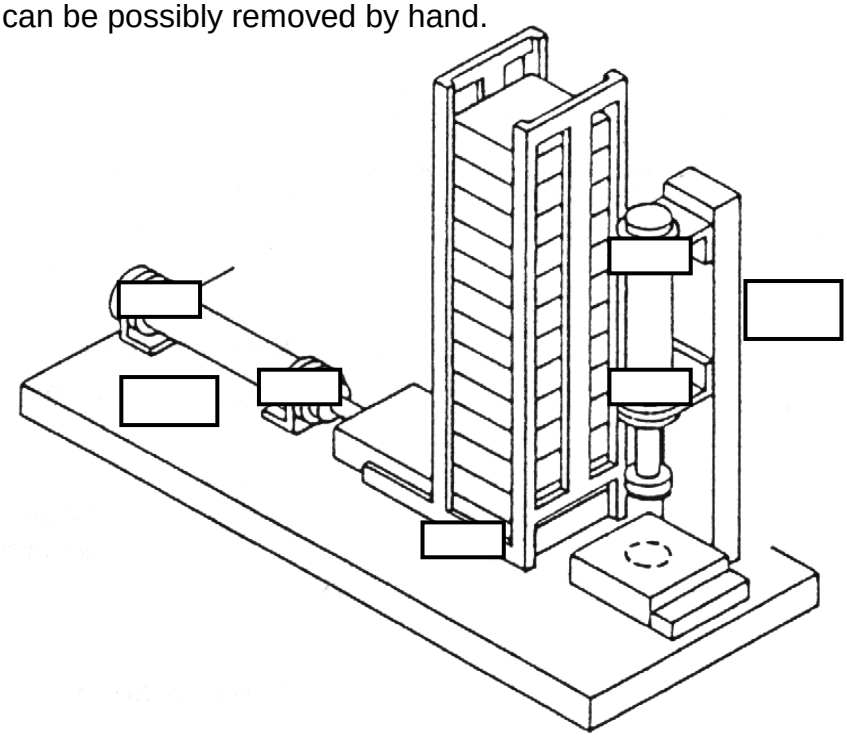
Presentation of the Problem

Aluminium workpieces should be marked in a stamping device.

Procedure

The operation is started by pressing the Start button, when the cylinder 1A1 is in the retracted position and the magazine is filled with workpieces.
The cylinder 1A1 pushes the workpieces from the magazine stack and clamps it to a stop.
The cylinder 2A1 moves down the stamp. After the stamping process the cylinder 2A1 goes back into the starting position. In the end the cylinder 1A1 releases the workpiece, which can be possibly removed by hand.

Layout



Tasks

Create an electro-pneumatic solution

To solve this task, follow these steps::

	✓
1. Fill in the correct item designation (Figure above).	
2. Choose a suitable proximity sensor for the magazine query.	
3. Study the information for sequence chain for the electro-pneumatic solution.	
4. Draw and simulate your circuit including a equipment list.	
5. Construction: With your schematics (from FluidSIM) build on an electro-pneumatic solution.	

Sequence chain

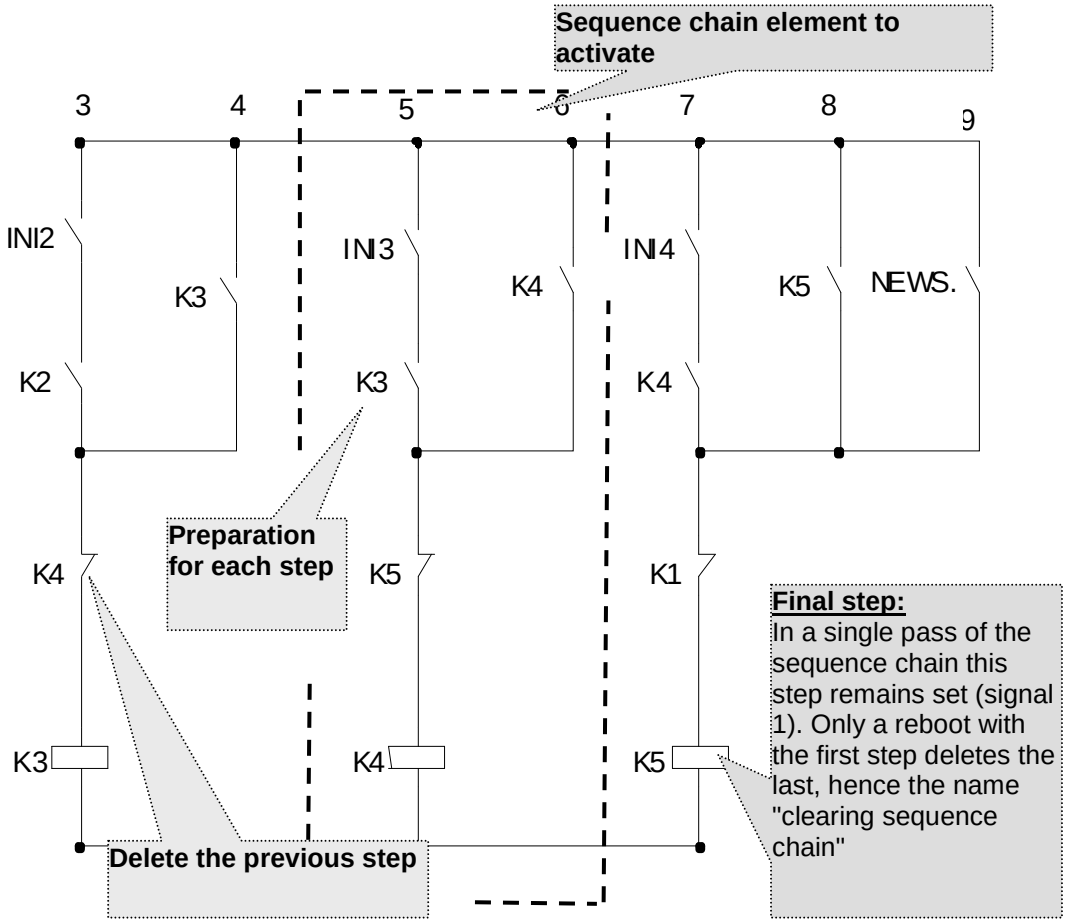
Sequence chains can avoid the problem signal overlap. Extensive tasks with more than two actuators can be planned and carried out easily and safely. Sequence chain controls are therefore a suitable solution for complex automation tasks and frequently used as an industrial standard.

Principle of a sequence chain:

Apply the following **rules for the sequence chain control**:

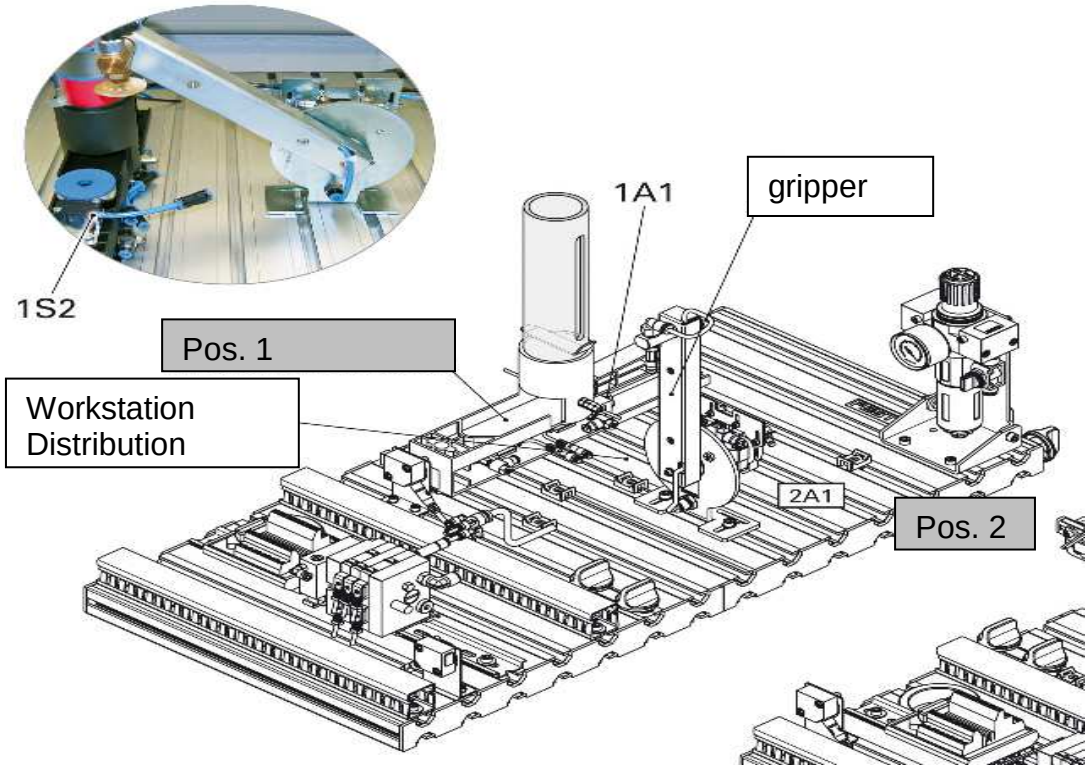
- Each end position of an actuator operates a signal element (e. g. limit switch).
- Each active step must be provided with a self holding.
- The next step of a sequence chain is only possible, if the previous step has been executed (K3 in path 5).
- The now active step resets the previous step (Normally closed contact K4 in path 3).
- During execution the last step prepares the first step (the first step of the sequence chain would need a normally closed contact of K5). In case of a complete new start of the sequence chain there is no last step that prepares the first one. Therefore the first step has to be prepared by an additional signal element (instead of the normally closed contact of K5 by the NEWS. button in path 9).

Example of a sequence chain (clearing):

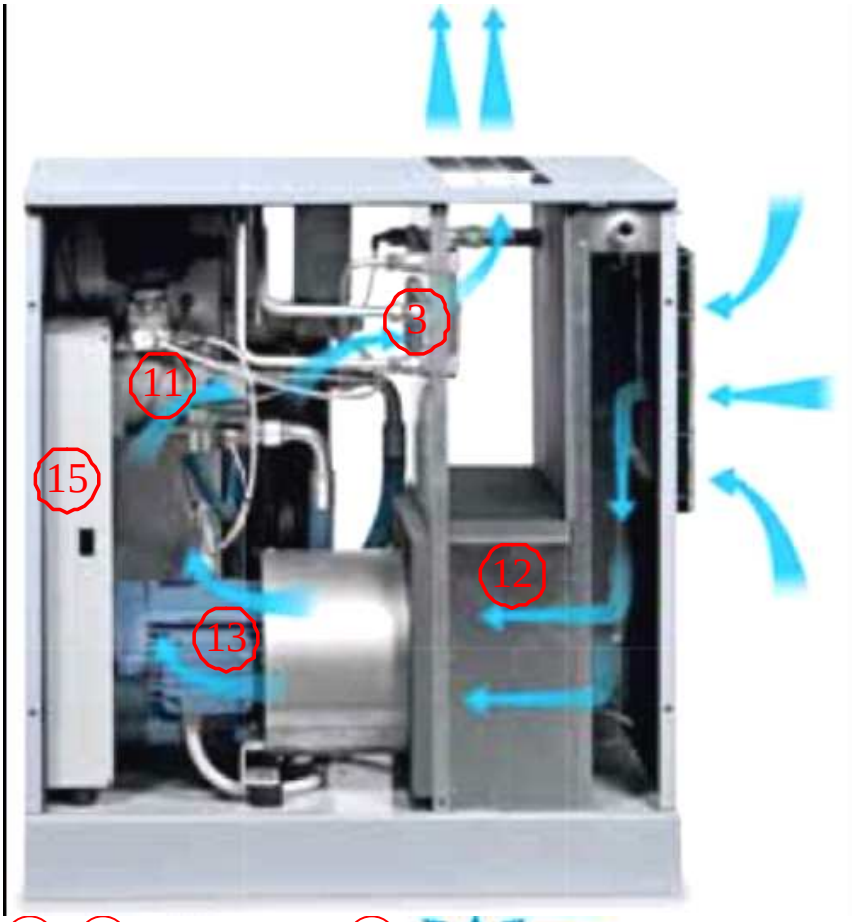


Information

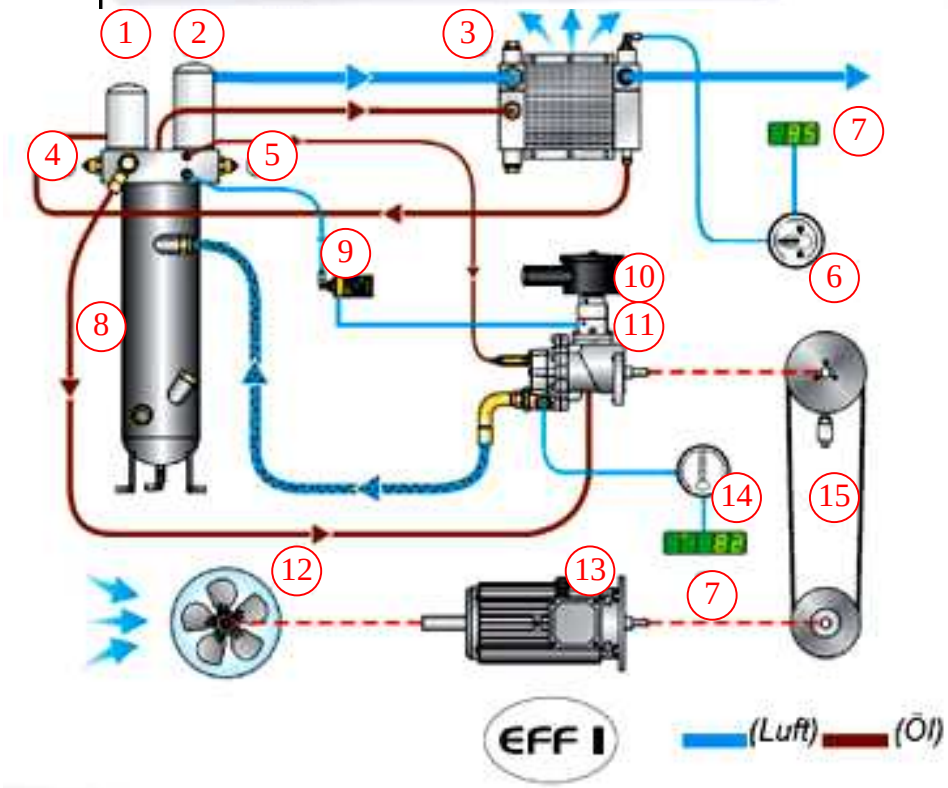
Module Electro-Pneumatics



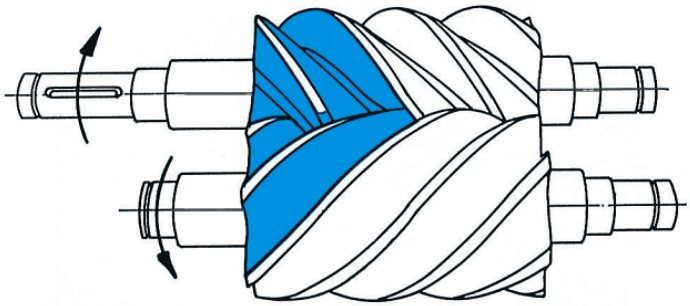
Mark rotary screw compressor MSA 7,5/10



The fresh air is sucked through the fan (12), driven by the electric motor (13). The electric motor does turn the rotary screw compressor (11) via the transmission group (15).
The rotary screw compressor (11) conveys the air from the suction to pressure side. It is supplied for lubrication oil.
The air /oil mixture is separated at the oil separator (2). Oil and air get cooled in the air/oil cooler (3). The cooled oil is cleaned by the oil filter (1) and fed back into the oil tank (8). The compressed air leaves the compressor through pipes.



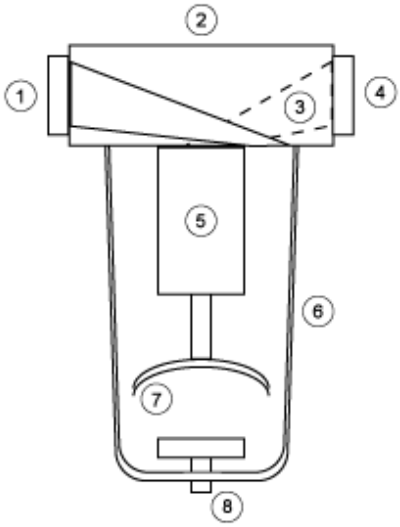
1 – Oil filter
2 – Air/oil separator filter
3 – Air/ oil cooler
4 – Safety valve
5- Thermostatic valve
6 – Pressure control
7 – Display
8 – Oil tank
9 – Suction Electro-valve
10 – Air suction filter
11 – Rotary screw
12 – Cooling fan
13 – Electric motor EFF1
14 – Temperature control
15 – Transmission Group



Rotary screw compressors use two meshing helical screws, known as rotors, to compress the gas. In an oil-flooded rotary screw compressor, lubricating oil bridges the space between the rotors, both providing a hydraulic seal and transferring mechanical energy between the driving and driven rotor. Gas enters at the suction side and moves through the threads as the screws rotate. The meshing rotors force the gas through the compressor, and the gas exits at the end of the screws

Oil Water Seperator

Oil/water separators are designed to separate compressor oil from condensate with high efficiency without the use of external power. Oily compressed air condensate should be effectively removed from the system by a level controlled drain like the *ZANDER* ***ecodrain***.
Condensate from the system will enter under pressure, into the specially designed centrifugal inlet chamber (1).
Liquid will drop out of the air stream as it impinges on the chamber walls and the vortex generator, draining without turbulence into the primary settlement chamber (2) below.
Dirt particles suspended in the condensate will settle to the bottom of the primary settlement chamber and the accumulating condensate will then flow into the main settlement tank(3).
Entrained droplets of oil dispersed in water will rise to the surface due to the lower specific gravity of the oil, eventually coalescing to form a thick layer on the surface.
An adjustable oil funnel (4) allows the oil to be continuously skimmed off the surface. Drained oil is collected in the external oil container (5) where it can be disposed of according to legal requirements.
Cleaner water taken from the bottom of the tank flows into the carbon stage (6), through a prefilter (7), into the top of the carbon bags.
Any entrained droplets of oil remaining are then removed by adsorption.
The cleaned water can now be safely discharged to the foul sewer through the outlet (8).



Drawing of typical industrial air filter.

Filters for Compressed Air

Filters

Filters of all kinds are found everywhere in the world, and most of us are familiar with some of them. The proper selection and use of compressed air filters will prevent many short and long term problems with your compressed air equipment and systems and save you substantially in down-time and component replacement costs over the life of your compressed air system.
The standard compressed air filter will contain the following components. The numbers on the picture of the compressed air filter picture correspond to the description in the text.

1) Air inlet; Air flows through the inlet. The cap is plumbed internally to force the air to flow downwards and spiral into to the filter bowl. This "cyclonic action" will "throw" free water and debris that may be in the air against the walls of the bowl, where it will flow down into the bottom.

2) The filter cap; Correct air filter operation depends on the air flowing through the unit in the correct direction from the supply line out the filter discharge. The correct air flow direction will almost always be identified on the cap of the filter, usually with an arrow. The arrow points in the desired direction of air flow from the supply line to the filter discharge. The air filter will not work properly if you inadvertently reverse the air flow.

3) The dotted line shows the flight path of the compressed air as flows toward the filter discharge. In order to exit the filter through this path, the compressed air must have undergone the cyclonic action phase, and then passed through the filter element, further purifying the airstream.

4) This is the filter discharge; allowing the flow of the filtered compressed air from the filter and down the air line to your applications. While it's feasible to use a larger filter unit on the small air line, attempting the reverse may impede compressed air flow. Do not do this unless you've checked to ensure that the flow of the smaller air filter has sufficient flow capacity for your application.

5) This is the filter element; Insufficient air supply problems encountered downstream from your compressed air filter are often caused by the element becoming plugged and choking your air supply. If your air tool or applications isn't getting enough air, check the element. Clean it or replace it, depending on the type.

Filter elements have a specific flow capacity measured in CFM, and a particulate size rating measured in Microns.

The chart beside tells you the actual size particle that a specific Micron rating represents.

Micron	Inches
5	0.0002
10	0.0004
15	0.0006
20	0.0008
40	0.0016

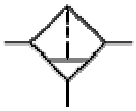
General purpose filter elements are 30 or 40 Micron sized. For some applications, you'll want a 5 Micron element, however, depending on your air quality, an element that 'fine' will clog quickly. It's common, then, to use a general purpose filter upstream from the unit with the 5 Micron element, to increase it's life.

6) The filter bowl of your air filter may thread into the cap housing, or more likely use a "bayonet" type mount. The bayonet style of mount can be installed by pushing the bowl up against the cap, rotating it a short distance, and letting the lugs on the bowl slide down into the receptacles in the cap. To remove the bowl, you reverse the process.

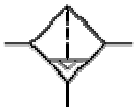
7) Bowl Separation Barrier; Inside of almost every air filter bowl there will be a device that separates the bowl into an 'above' and 'below' section. This barrier is usually made of a plastic or plastic composite and is usually installed hanging from the bottom of the element. This barrier blocks the cyclonic incoming air, preventing it from reaching the "soup" of debris, water and oil that's collecting in the bottom of the filter bowl. This barrier creates a "quiet" zone, allowing the contamination that collects onto the sides of the bowl to flow down, ultimately out of the cyclonic air, and to remain - without getting entrained or re-entrained back into the air stream, until it can be expelled from the drain at the bottom of the bowl.

8) Drain; All industrial compressed air filters will have a drain in the bottom of the bowl. These drains may be manual, float type, or electronic auto drains. They need to be opened regularly to allow collected water and debris to escape from the filter bowl. Failure to drain the filter bowls often enough will mean that the water and debris in the "quiet zone" will rise past the barrier referred to above, and once there, be entrained into the "cyclonic" air, and onto the element.

Here are the generally accepted symbols for drawing compressed air filters in your circuit schematic.



Symbol for compressed air filter / water separator with manual drain

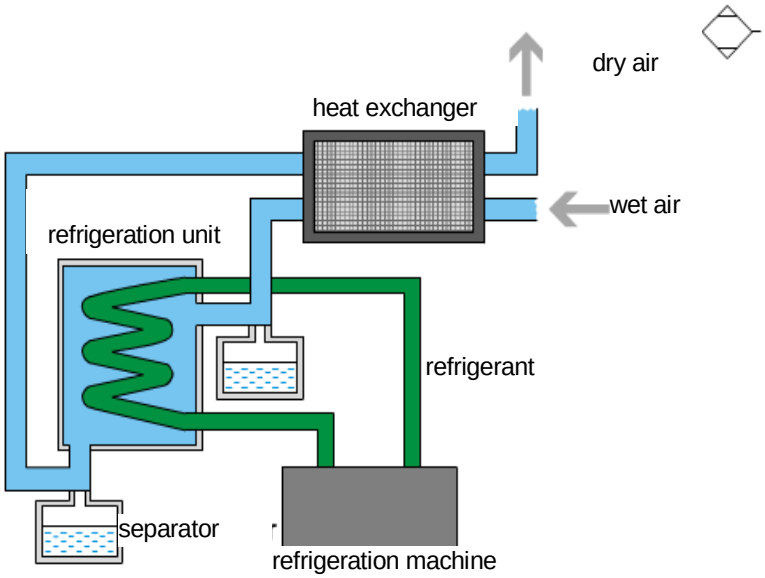


Symbol for compressed air filter / water separator with automatic drain

Refrigerated Air Dryer

Refrigerated Air Dryers can help you solve the problem of harmful moisture in your compressed air system. Excess moisture in your system can harm equipment and ruin processes or product, costing you time and money.

COMPRESSED AIR CIRCUIT



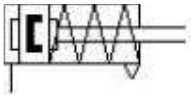
- The refrigerated air dryer cools the incoming compressed air first in an air-to-air heat exchanger where the outgoing cool dry air pre-cools the hot incoming air and condenses some moisture out.
- Then the incoming air enters an air-to-refrigerant heat exchanger where the air is cooled to 38º F by the liquid refrigerant.
  This process causes the moisture to condense into liquid water and it is drained away.
  The out going air then enters the air-to-air heat exchanger and is warmed up to keep the outside of pipes from sweating.

REFRIGERATION CIRCUIT

- The refrigeration compressor pumps hot hi-pressure gas refrigerant (Freon) into the condenser which transfers the heat from the refrigerant gas to the ambient air as the gas condenses into a liquid.
- The liquid refrigerant (Freon) is then metered to a cold low pressure where it enters the air-to-refrigerant heat exchanger and the heat from the hot compressed air is adsorbed into the cold refrigerant (Freon).
- The refrigeration compressor then sucks low pressure hot gas refrigerant (Freon) into the refrigeration compressor and the cycle starts over again**.**

1. Single-acting cylinder

152887
Single-acting cylinder



Design

The single-acting cylinder with trip cam and push-in fitting is mounted on a plastic retainer. The unit is mounted on the profile plate via quick release detent system with two blue trip grip nuts (mounting alternative "B").

Function

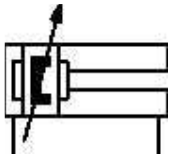
The piston rod of the single-acting cylinder moves into the forward end position through the supply of compressed air. When the compressed air is switched off, the piston is returned to the retracted end position via a return spring. The magnetic field of a permanent magnet, which is attached to the cylinder piston, actuates the proximity switches.

Technical data

Pneumatic	
Medium	Compressed air, filtered (lubricated or unlubricated)
Design	Piston cylinder
Operating pressure max.	1000 kPa (10 bar)
Piston diameter	8 mm
Max. stroke length	50 mm
Thrust at 600 kPa (6 bar)	139 N
Spring return force min.	13.6 N
Connection	QS-G1/8-4 fittings for plastic tubing PUN 4 x 0.75

2. Double acting cylinder

152888
Double-acting cylinder



Design

The double-acting cylinder with trip cam and push-in fittings is mounted on a plastic retainer. The unit is mounted on the profile plate via a quick release detent system with two triple grip nuts (mounting alternative "B").

Function

The piston rod of the double-acting cylinder is reversed by means of alternating supply of compressed air. End position cushioning at both ends prevents a sudden impact of the piston on the cylinder housing. The end position cushioning can be adjusted by means of two regulating screws. The magnetic field of a permanent magnet attached to the cylinder piston actuates the proximity switches.

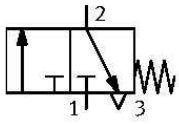
Technical data

Pneumatic	
Medium	Compressed air, filtered (lubricated or unlubricated)
Design	Piston cylinder
Operating pressure max.	1000 kPa (10 bar)
Piston diameter	8 mm
Max. stroke length	100 mm
Thrust at 600 kPa (6 bar)	189 N
Return force at 600 kPa (6 bar)	158 N
Connection	QS-G1/8-4 fittings for plastic tubing PUN 4 x 0.75

3. 3/2-way valve pushbutton actuator, nc

152860

3/2-way valve with pushbutton actuator, normally closed



Design

The 3/2-way valve with pushbutton actuator, normally closed is assembled in a polymer housing. The unit is mounted on the profile plate via a quick release detent system with blue lever (mounting alternative "A").

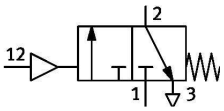
Function

The valve is actuated by pressing the pushbutton. Releasing of the pushbutton returns the valve to the normal position via a return spring.

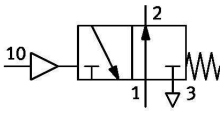
Technical data

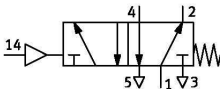
Pneumatic	
Medium	Compressed air, filtered (lubricated or unlubricated) (or vacuum; port 1)
Design	Poppet valve, directly actuated on one side, with return spring
Actuation	Pushbutton
Pressure range	-90 – 800 kPa (-0.90 – 8 bar)
Standard nominal flow rate 1...2	60 l/min
Actuating force at 600 kPa (6 bar)	6 N
Connection	QSM-4 fittings for plastic tubing PUN 4 x 0.75

4. 3/2-way pneumatic valve pneumatically actuated one side



or

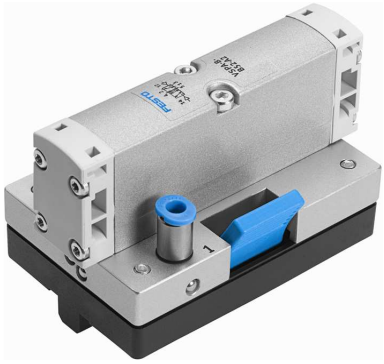




The internal structure of this valve

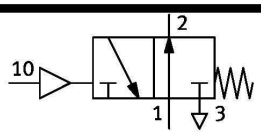
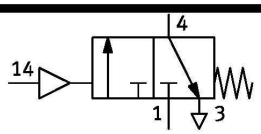
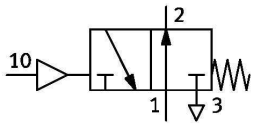
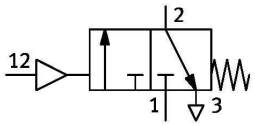
539768

3/2-way pneumatic valve, pneumatically actuated, one side



Design — The 5/2-way pneumatic valve with push-in connectors and a single blanking plug is screwed on to an assembly base, which is equipped with supply port and silencers. The unit is mounted on the profile plate via a quick release detent system with blue lever (mounting alternative „A“).

Note — The valve ports are identified by numbers:

Normally open	**Normally closed**
	
1 = Supply port	1 = Supply port
2 = Working or outlet ports 10 = Pilot	4 = Working or outlet ports 14 = Pilot
3, 5 = Exhausts (via silencers in function plate)	3, 5 = Exhausts (via silencers in function plate)
Symbol used in the circuit diagram/circuit design: 	Symbol used in the circuit diagram/circuit design: 

3/2-way pneumatic valve, pneumatically actuated, one side 539768

Function The pneumatic valve switches at port 14 (Z) (10 (Z)) via a pneumatic signal and is returned to the initial position via a spring when the signal has been removed.

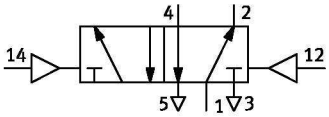
Technical Data

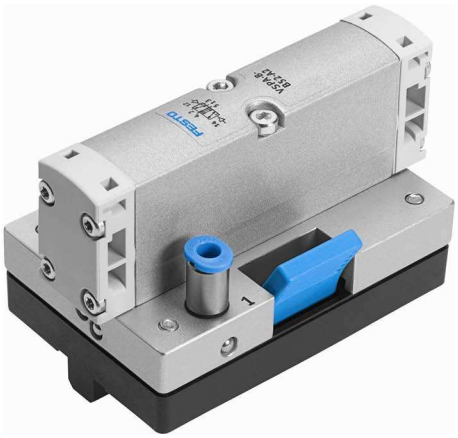
Pneumatic	
Medium	Compressed air, filtered
Design	Spool valve, indirectly actuated on one side, with return spring
Pressure range	200 to 1000 kPa (2 to 10 bar)
Operating pressure range	-90 to 1000 kPa (-0.9 to 10 bar)
Standard nominal flow rate 1…2, 1...4	500 l/min
Switching time at 600 kPa (6 bar)	On: 8 ms Off: 18 ms
Connection	QS-1/8-4-I, QSM-M5-4-I fittings for plastic tubing PUN 4 x 0.75

5. 5/2-way double pilot valve pneumatically actuated both sides

539769

5/2-way double pilot valve, pneumatically actuated, both sides





Design

The 5/2-way double pilot valve with push-in fittings is screwed onto the function plate, which is equipped with supply port and silencers. The unit is mounted on the profile plate via a quick release detent system with blue lever (mounting alternative "A").

Function

The double pilot valve is actuated by applying pneumatic signals alternately to ports 14 and 12. It remains in its last switched position until a counter signal is received.

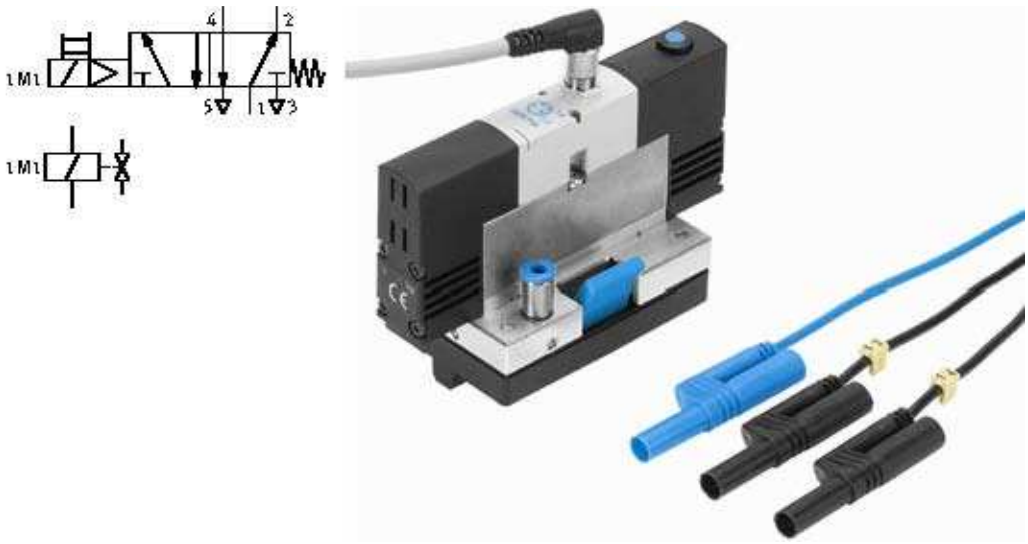
Technical Data

Pneumatic	
Medium	Compressed air, filtered (lubricated or unlubricated) or vacuum
Design	Spool valve, directly actuated on both sides
Control pressure range	200 to 1000 kPa (2 to 10 bar)
Operating pressure range	-90 to 1000 kPa (-0.9 to 10 bar)
Standard nominal flow rate 1...2, 1...4	500 l/min
Response time at 600 kPa (6 bar)	6 ms
Connection	QS-1/8-4-I, QSM-M5-4-I fittings for plastic tubing PUN 4 x 0.75

6. 5/2-way single solenoid electric valve

539777

5/2-way single solenoid valve with LED



Design	The 5/2-way solenoid valve is mounted using push-in fittings onto the function plate, which is equipped with a supply port and silencer. The two electrical connections are equipped with safety connectors. The unit is mounted on the profile plate using a snap-lock system with a blue lever (mounting variant "A").
Function	The solenoid valve is reversed when voltage is applied to the solenoid coil (1 →4) and brought back into its initial position (1 → 2) by a return spring when the signal is removed. The switching status is shown by an LED in the terminal housing. The valve is equipped with a manual override.
Note	The solenoid coil is characterised by very low power consumption and low heat generation. The electrical connection incorporates protection against incorrect polarity for the LED and a protective circuit.

5/2-way single solenoid valve with LED

539777

Technical Data

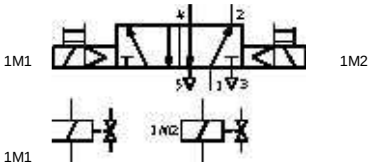
Pneumatic	
Medium	Compressed air, filtered (lubricated or unlubricated)
Design	Spool valve, pilot-actuated, with return spring
Pressure range	300 to 800 kPa (3 to 8 bar)
Switching time at 600 kPa (6 bar)	On: 25 ms OFF: 40 ms
Standard nominal flow rate	500 l/min
Connection	QS-1/8-4-I fittings for plastic tubing PUN 4 x 0.75

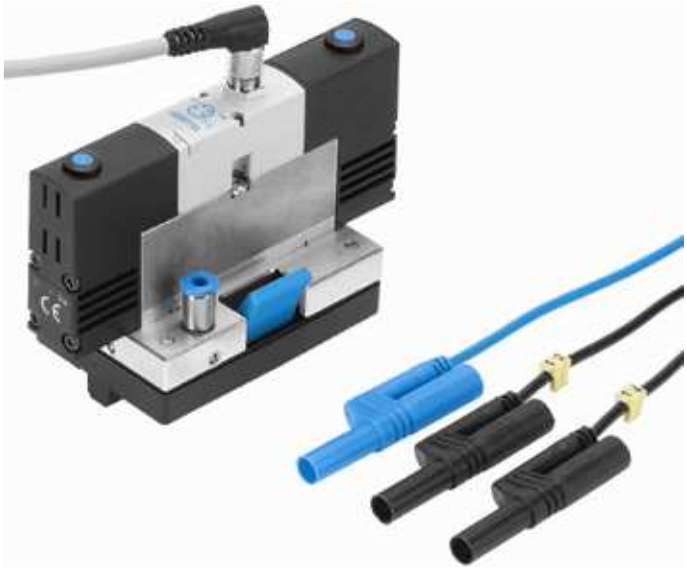
Electrical	
Voltage	24 V DC
Duty cycle	100 %
Protection class	IP65
Connection	M8x1 central plug, cable with socket and 4 mm safety plugs

7. 5/2-way double solenoid electric valve

539778

5/2-way double solenoid valve with LED





Design	The 5/2-way double solenoid valve is mounted using push-in fittings onto the function plate, which is equipped with a supply port and silencer. The four electrical connections are equipped with safety connectors. The unit is mounted on the profile plate using a snap-lock system with a blue lever (mounting variant
Function	The double solenoid valve is reversed when voltage is applied to a solenoid coil and remains in this switching position after the signal is removed until an opposed signal is applied. The presence of switching signals is shown by the LEDs in the terminal housings. The valve is equipped with a manual override.
Note	The solenoid coil is characterised by very low power consumption and low heat generation. The electrical connections incorporate protection against incorrect polarity for the LEDs and protective circuits.

5/2-way double solenoid valve with LED

539778

Technical Data

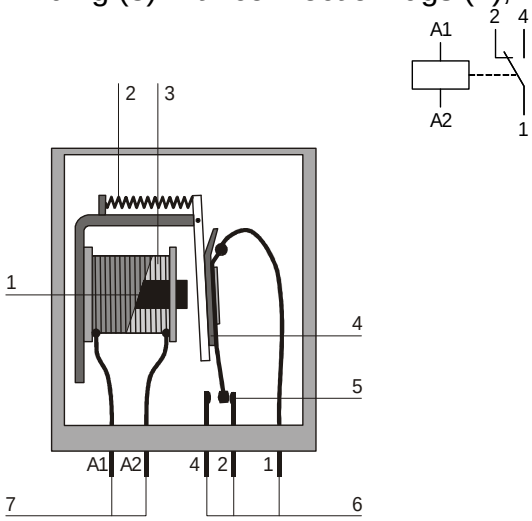
Pneumatic	
Medium	Compressed air, filtered (lubricated or unlubricated)
Design	Spool valve, pilot-actuated
Pressure range	300 to 800 kPa (3 to 8 bar)
Switching time at 600 kPa (6 bar)	15 ms
Standard nominal flow rate	500 l/min
Connection	3 QS-1/8-4-I fittings for plastic tubing PUN 4 x 0.75

Electrical	
Voltage	24 V DC
Duty cycle	100 %
Protection class	IP65
Connection	M8x1 central plug, cable with socket and 4 mm safety plugs

8. Relay

Function

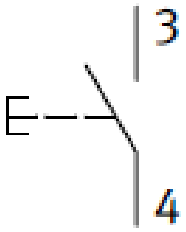
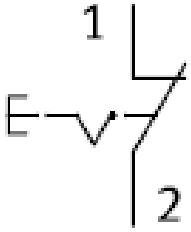
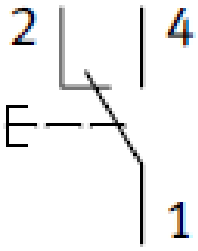
The relay consists of a coil with a core (1) and winding (3) with connection lugs (7), an armature (4), a return spring (2) and a contact assembly with four changeover contacts (5) and connection lugs (6). When power is applied to the coil connections, current flows through the winding, creating a magnetic field. The armature is pulled onto the coil core and the contact assembly is actuated. Electrical circuits are opened or closed via this assembly.
When the electrical current is removed, the magnetic field collapses and the armature and contact assembly are returned to their original position by a return spring.



Note

The switching status of the relays is indicated by LEDs, which are protected against incorrect polarity. The four changeover contacts of the contact assembly can be used as normally-open contacts (1), normally-closed contacts (2) or changeover contacts (4).
(check the Information for contacts)

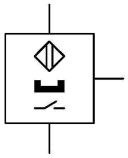
9. Contacts

Symbol	Design / Function
	**Design**: Pushbutton with normally open contacts **Function**: In the case of a pushbutton, the selected switching position is only retained as long as the pushbutton is activated. The pushbutton shown here has a normally open function. With normally open contacts, the electrical circuit is interrupted when the pushbutton is in its normal position, i.e. in the inactivated state. When the control stem is actuated, the electrical circuit is closed and current flows to the consuming device. When the control stem is released, the pushbutton is returned to its normal position by means of spring force and the electrical circuit is interrupted.
	**Design**: Switch with normally closed contacts **Function**: Switches are mechanically locked into the two switching positions. The respective switching position is retained until the switch is once again activated. The control switch shown here has a normally closed function. In the case of normally closed contacts, the electrical circuit is closed when the control switch is held in its normal position by means of spring force. When the control switch is activated, the electrical circuit is interrupted and reactivation closes the circuit again.
	**Design**: Pushbutton with change-over contacts **Function**: In the case of a pushbutton, the selected switching position is only retained as long as the pushbutton is activated. The pushbutton shown here has a change-over function. In the case of change-over contacts, NC and NO functions are combined into a single component. An electrical circuit is closed and another is interrupted with a single switching operation. Both circuits are briefly interrupted during switching.

10. Magnetic proximity sensor

540695

Proximity sensor, electronic

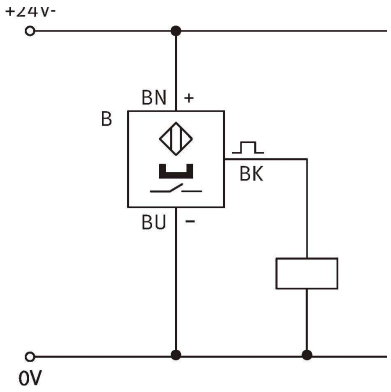


Design

The proximity sensor consists of the sensor, mounting kit and cable. The cable is equipped with a socket and three jack plugs.

Function

This proximity sensor emits an electrical signal when approaching a magnetic field (e.g. permanent magnet on a cylinder piston). The electrical connections are moulded into the cable. The switching status is indicated via an LED. The yellow LED is illuminated when actuated.



Note

The polarity of the applied voltage is to be observed for the correct functioning of the device. The wires inside the socket cable must therefore be allocated by colour: Red (BN) for positive, blue (BU) for negative and black (BK) for the signal output. In this case, the load (relay) is connected to the sensor and to the negative pole. The switch is protected against reverse polarity but not against short circuit.

Proximity sensor, electronic

540695

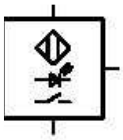
Technical data

Electrics	
Switching voltage	10 to 30 V DC
Switching current	Max. 200 mA
Switching accuracy	±0.1 mm
Switching time	On: 0.5 ms Off: 0.5 ms
Connection	M 8x1 plug socket for socket with cable
Cable	With 4 mm jack plug
Electromagnetic compatibility	CE
Emitted interference	Tested to EN 500 81-1
Noise immunity	Tested to EN 500 82-1

11. Optical proximity sensor

178577

Proximity sensor, optical



Design

The optical proximity sensor with LED and electrical connections is assembled on a polymer assembly base. The electrical connection is effected by means of safety connectors. The unit is mounted on the profile plate via a quick release detent system with blue triple grip nut (mounting alternative “B”).

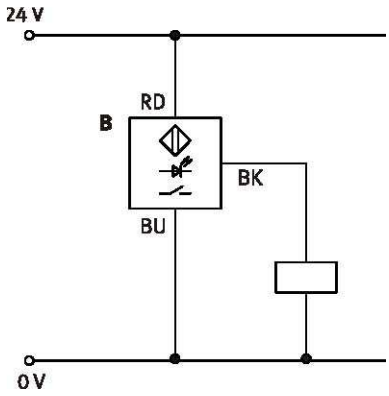
Function

Optical proximity sensors consist of two main modules, the emitter and the receiver. In the case of diffuse sensor, these are built into one housing. The emitter of the diffuse sensor emits a pulsating, red light which is within the visible spectral range. The object to be detected reflects part of the light emitted. This light is detected by a semiconductor device in the receiver which is also built into the sensor housing and causes a change in the switching status.

The object to be detected may be reflective, matt, transparent or opaque. All that is needed is for a sufficiently high proportion of light to be reflected directly or diffusely.

The operational switching distance may be varied by means of a potentiometer. The proximity sensor has a PNP output, i.e. the signal line is switched to the positive potential in the switched status. The switch is designed as a normally closed contact. The connection of the load takes place between the signal output of the proximity sensor and the load. The switching status is indicated by a yellow LED. The sensor is protected against polarity reversal, overload and short circuit.

178577



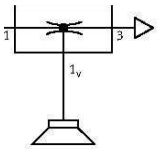
Note

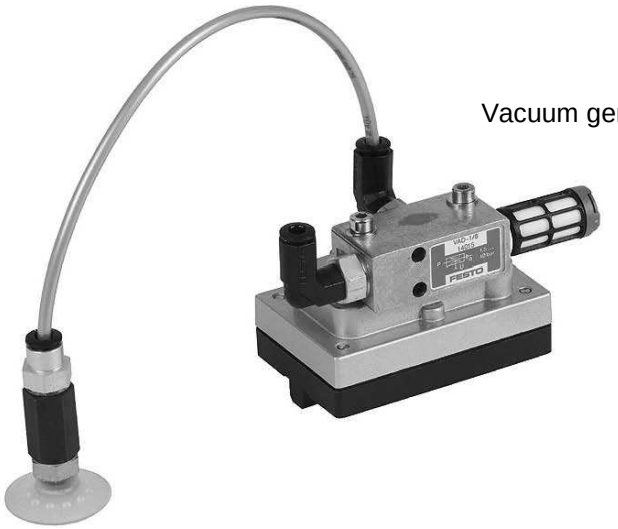
The correct polarity of the applied voltage is necessary for proper functioning. The connections for the operating voltage are colour coded as follows: red for positive, blue for negative and black for the signal output. The load is connected to the switching output and the negative terminal of the current supply.

Technical Data

Electrical	
Switching voltage	10 – 30 V DC
Residual ripple	maximum 10%
Nominal switching distance	0 to 100 mm (adjustable)
Switching frequency	maximum 200 Hz
Output function	Normally open contact, positive switching
Output current	maximum 100 mA
Protection class	IP65
Connections	for 4 mm safety connector plug
Cable	with 4 mm safety connector plug
Electromagnetic compatibility	CE
Eitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

12. Vacuum generator





152891

Vacuum generator/suction cup

Design

The vacuum generator with push-in elbow fitting and suction cup is mounted on an assembly base. The unit is mounted on the profile plate via a quick release detent system with blue lever (mounting alternative „A“).

Function

The vacuum generator creates vacuum when compressed air flows from ports 1 to 3 on the basis of the ejector principle. The suction cup is to be connected to vacuum connection 1V. The suction process stops if the compressed air at 1 is switched off.

Note

The valve ports are identified by numbers: 1 = Supply port 1V = Vacuum connection 3 = Exhaust

Technical data

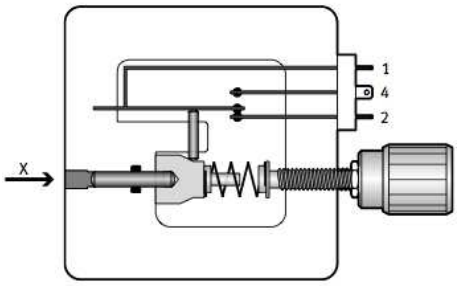
Pneumatic	
Medium	Compressed air, filtered (lubricated or unlubricated)
Design	Ejector principle
Pressure range	150 – 1000 kPa (1.5 – 10 bar)
Vacuum at 600 kPa (6 bar)	Minimum 85 kPa (0.85 bar)
Air consumption at 600 kPa (6 bar)	15 l/min
Switching frequency at 600 kPa (6 bar)	Maximum 10 Hz with 1 m tube
Connection	QSL-1/8-4, QS-1/8-4-I fittings for plastic tubing PUN 4 x 0.75

13. Pressure switch

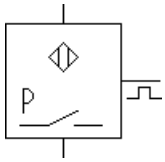
Pressure sensors can be subdivided into two groups. Differentiation is made between:

- Pressure sensors with mechanical contact (mechanical mode of operation)
- Pressure sensors with electronic switching (electronic mode of operation)

Schematic drawing:



Circuit symbol:



Description: task and function:

Pressure switches are used in order to generate an electrical output signal when a specified pressure is reached.
In the case of this mechanical pressure switch, pressure acts on the surface of a piston. If the force generated by prevailing pressure exceeds the force of the spring used, the piston moves and actuates the change-over contact points.
Switching pressure can be adjusted by preloading the spring, which is why this pressure sensor is called a pressure switch.

This action based training was developed within the Leonardo Da Vinci Transfer of Innovation Project:

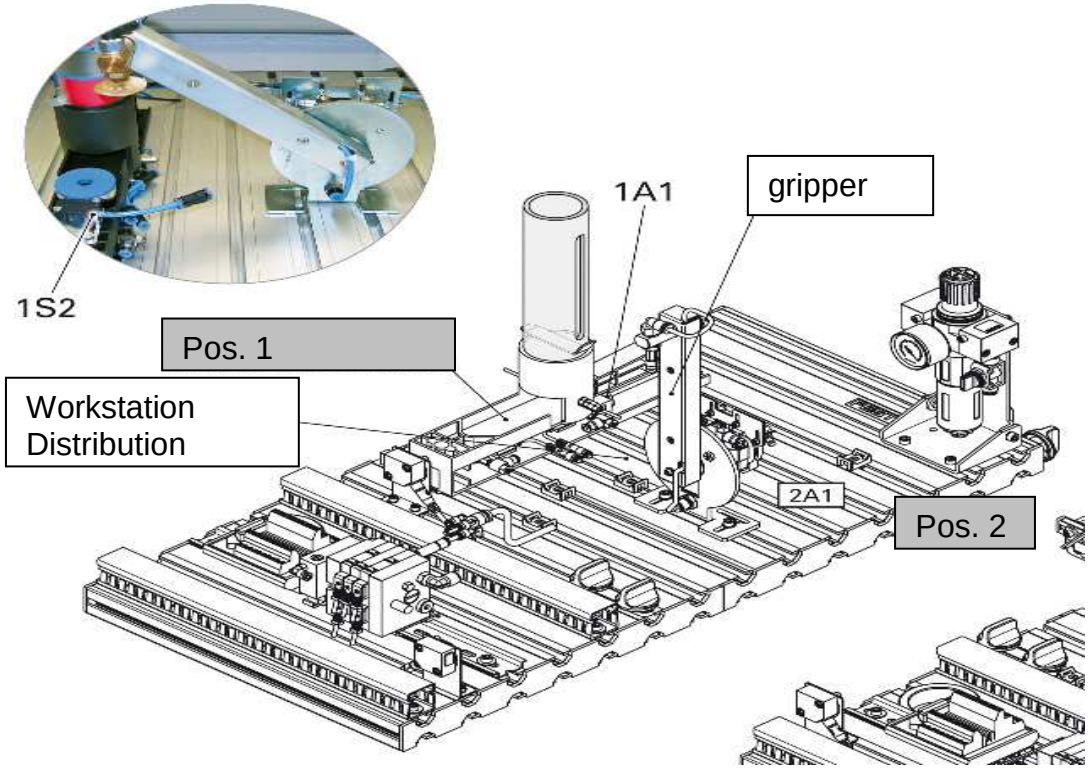
"MODULES FOR VOCATIONAL EDUCATION AND TRAINING FOR COMPETENCES IN EUROPA II"

"MOVET II"

(PROJECTNUMBER **DE/10/LLP-LdV/TOI/147341**)

Module Electro-Pneumatics

Learning Material for teachers



The aim of the training is to enable the apprentices to develop the skills, knowledge and competence for competence area 7 of the competence Matrix Mechatronics from the VQTS model (cf. Karin Luomi-Messerer & Jörg Markowitsch, Vienna 2006)

7.2 He/She can master the selection of hardware, software and industrial components for mechatronic systems (sensors, actuators, valves, relays, interfaces, communication procedures). He/she can provide and test simple software control programs (SPS) and develop and design simple control programms according to production process requirements (adaption of 7.2)

Instruction Sheet

The electro-pneumatics module has the following structure:

Unit	Content
Unit 1	**Safety**: you will learn how to work safely with the electro-pneumatic equipment.
Unit 2	**Production of compressed air**: you will learn how compressed air is produced.
Unit 3	**Work orders 1-6**: you will learn how to solve problems in automation technology using electro-pneumatics. Every work order consists of a part that contains the tasks and information you might need to help you solving the problems.
Unit 4	**Glossary**: here you find the necessary technical terms in your language

In every work order you will proceed through the following steps:

- **Information**: Study your work order also using the provided information material.
- **Planning**: Plan, develop and simulate with FluidSIM.
- **Realisation**: Realise your solution on the profile plate with electro-pneumatic components.
- **Checking**: Check your own work using your evaluation sheet.
- **Evaluation**: Evaluate your work together with your teacher using your evaluation sheet.

Evaluation work orders

Every work order is going to be evaluated in two steps.

(There is a maximum of 5 points for the tasks, 10 points for the circuit diagram and 15 for the function)

Self check:

First you check if all the tasks, the circuit diagram and the necessary functions of the work order are completed. Then you fill in the points you would give yourself.

Evaluation:

Then you are going through the same process with your teacher and see how she/he evaluates your work. All together you can get a maximum of 30 points for every work order.

Work orders		**Tasks 5P**	**Circuit Diagram 10P**	**Function 15P**	**Result**
WO 1	Self check				
	Evaluation				
WO 2	Self check				
	Evaluation				
WO 3	Self check				
	Evaluation				
WO 4	Self check				
	Evaluation				
WO 5	Self check				
	Evaluation				
WO 6	Self check				
	Evaluation				
Result				points	
				mark	

points	180-151	150-121	120-91	90-46	45-0
mark	**1**	**2**	**3**	**4**	**5**

1. Safety Precautions and work instructions

Learning outcomes:

After completing this work order:

You´ll be able to name and memorize (1F) the safety precautions and work instructions.

You´ll be able to identify (4Ca) hazardous situations

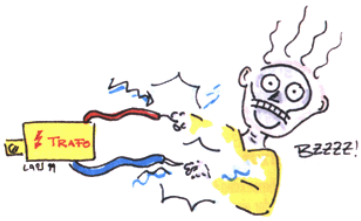
You´ll be able to formulate (5Ca) further safety precautions.

Tasks

1. Identify hazardous situations in your working environment.
2. Formulate further safety precautions and write them on the sheet.

Electrical:

- work only in the absence of voltage
- use low voltage only (24V vs. 230V)
- use only connector cables with safety plugs
- do not use defect electrical components



_____

_____

Mechanical:

- mount all components securely
- hands off the limit switches, push it only using a tool (e.g. screwdriver)
- hands off the moving parts
- actuate limit switches not frontally
- attention while troubleshooting
- work only in a standstill set-up

_____

_____

Pneumatics:

- danger when tubings slipping off
    - use short tubing connections
    - switch compressed air off immediately if tubing slips off
- push the tubing into the push-in connector as far as it will go
- the tubing can be pulled out, after pressing down the blue release ring
- don´t disconnect tubing while under pressure
- complete and secure all the tubing connections before switching on the compressed air
- attention: while switching compressed air on, cylinders may activate automatically
- maximum pressure of 6 bar
- use plastic tubing with an outside diameter of 4 or 6 mm
- switch off compressed air before dismantling the circuit

_____

_____

General:

- trainer instructions
- observe data sheets
- individual safety instructions

_____

_____

2. Production of compressed air

Learning outcomes:

After completing this work order:

You'll be able to tabulate and describe (1F) the components.

You'll be able to understand (2F) the flow diagram.

You'll be able to describe (2Ca) the valve settings.

You'll be able to summarize (2Ca) the production of compressed air

The following four components are important for producing compressed air:

- screw compressor
- filters
- oil-water separator
- absorption air dryer

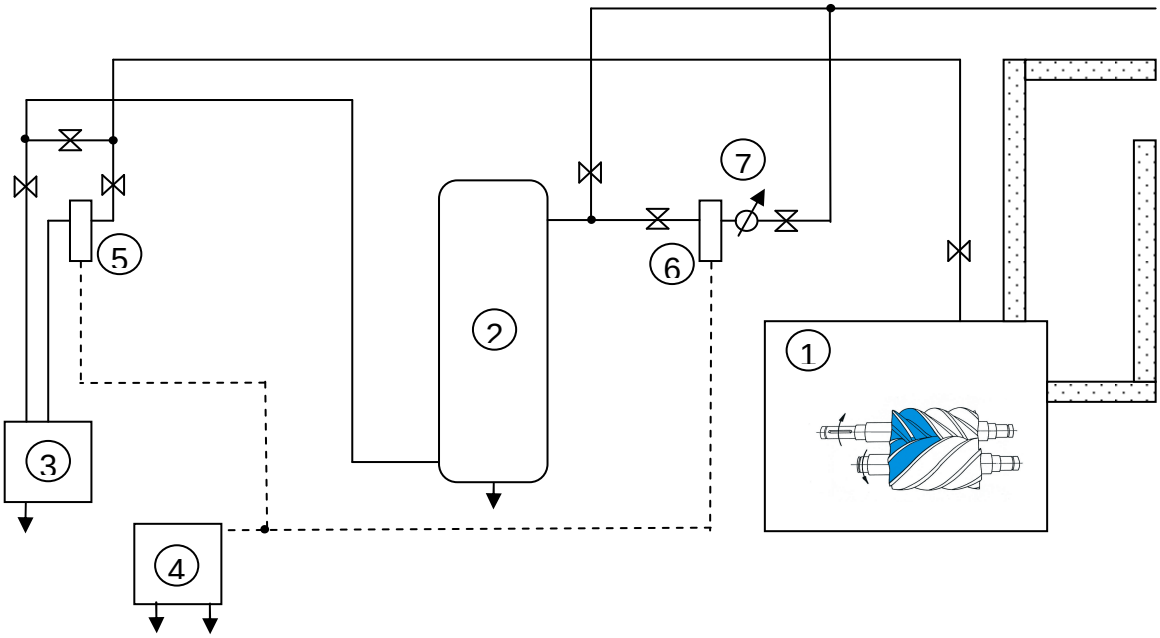
Form four different international teams and choose one of the components (best: one of each country) and do the following task:

Read through the Information of the chosen component and prepare a short spoken presentation/ speech (2-5 minutes) for the others.

The following aspects can be interesting:

- name of the component
- function of the component
- explain important vocabulary
- things of interest

Afterwards we are going to visit the place were the compressed air is produced in BSFT and each group identify and explain its part of the system.



Tasks

1. Fill in the components rightly in the table below

refrigerated air dryer / compressed air filter / compressed air reservoir / oil water separator / compressed air filter / pressure regulator / compressor /

1.	
2.	
3.	
4.	
5.	
6.	
7.	

2. Mark the lines in the diagram with the right colours:
   - warm compressed air: red
   - prepared air: blue
   - incoming air: green
   - exhaust air: orange
   - condensate line: yellow
3. Mark the closed valves ⋈ red and the open valves blue for normal operation
4. Describe in your own words the 4 steps from ambient air to cooled, clean compressed air. Use the colours from the diagram above.

Solution

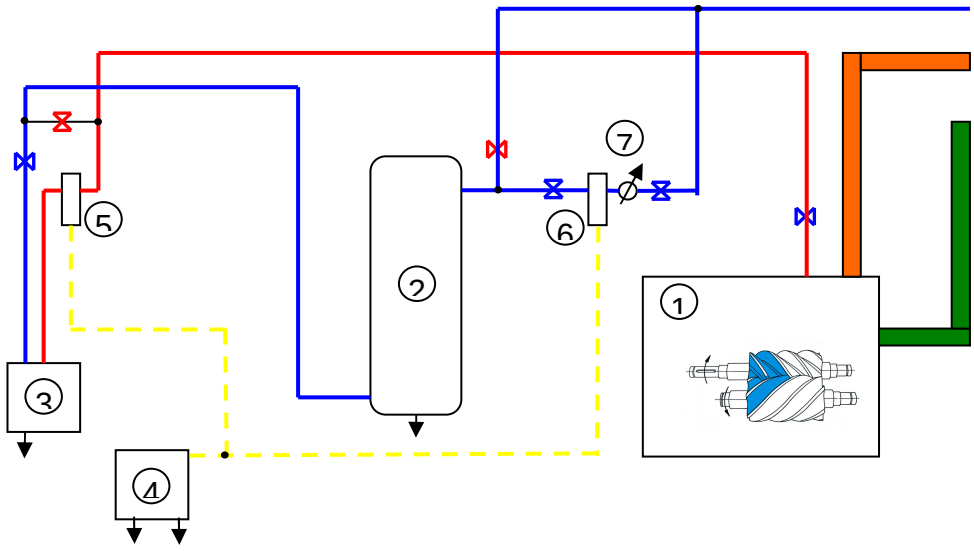
1. Fill in the components rightly in the table below

refrigerated air dryer / compressed air filter / compressed air reservoir / oil water seperator / compressed air filter / pressure regulator / compressor /

1	rotary screw compressor
2	compressed air reservoir
3	refrigerated air dryer
4	oil water separator
5	compressed air filter
6	compressed air filter
7	pressure regulator

2. Mark the lines in the diagram with the right colors:
   - warm compressed air: red
   - prepared air: blue
   - incoming air: green
   - exhaust air: orange
   - condensate line: yellow

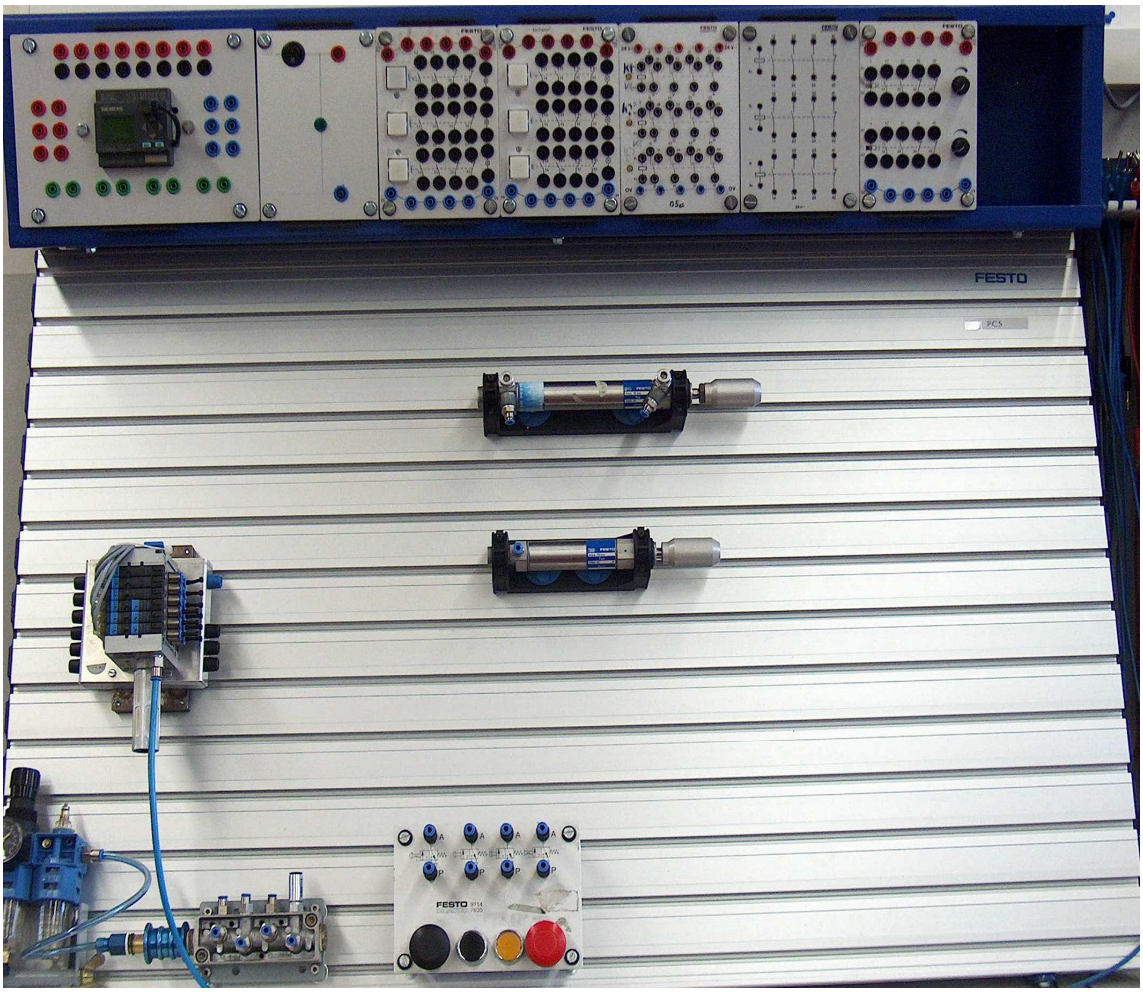
3. Mark the closed valves ⋈ red and the open valves blue for normal operation



4. Describe in your own words the 4 steps from ambient air to cooled, clean compressed air. Use the colours from the diagram above.

compress => clean => cool => clean

3. Work orders



3.1 Pneumatic basics (WO1)

Learning outcomes

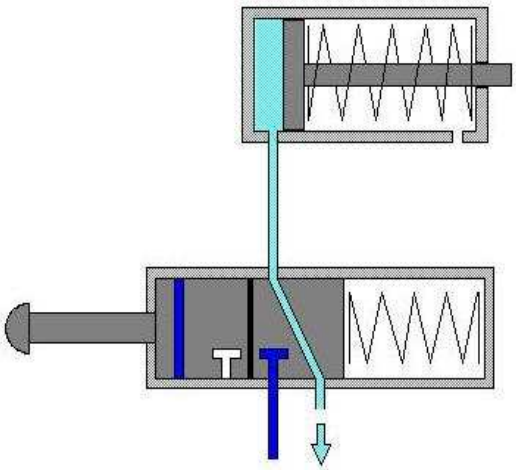
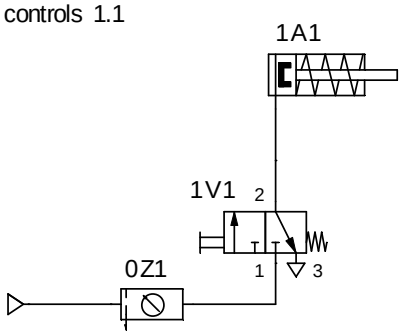
After completing this work order:

You'll be able to develop (3F) electro - pneumatic circuits by means of standard components.

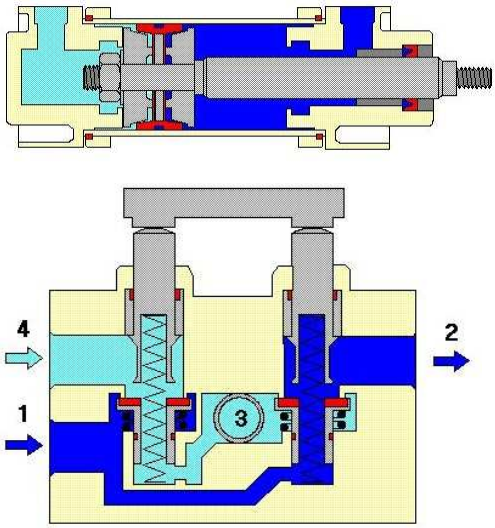
You'll be able to differentiate (2F) single and double acting cylinder, standard way valves, direct and indirect control of cylinders.

You'll be able to use (3F) the item designation systematically.

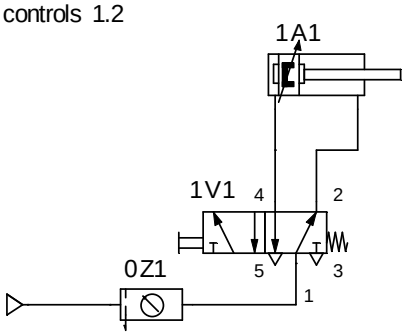
Pneumatic basic controls

function	pneumatic circuit
1.1 Direct control of a single acting cylinder	
	Basic controls 1.1 

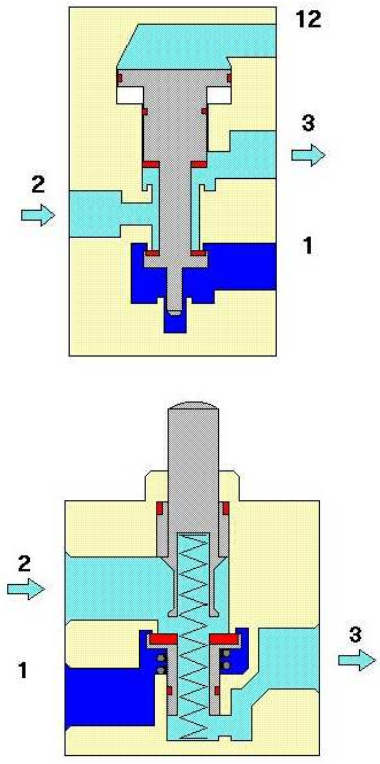
1.2 Direct control of a double acting cylinder



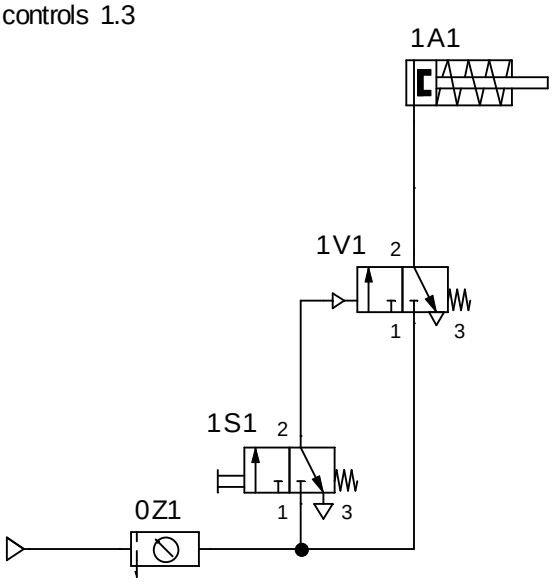
Basic controls 1.2



1.3 indirect control of a single acting cylinder via a monostable 3/2 way valve

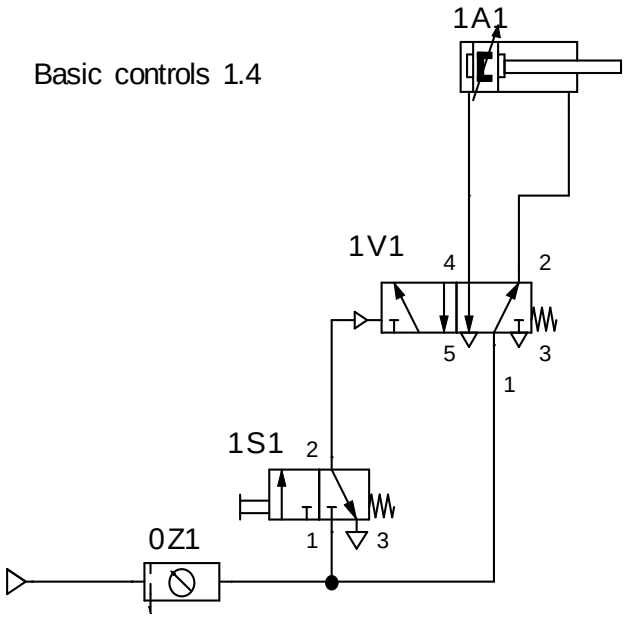


Basic controls 1.3

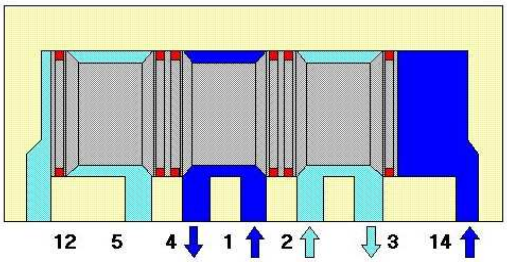


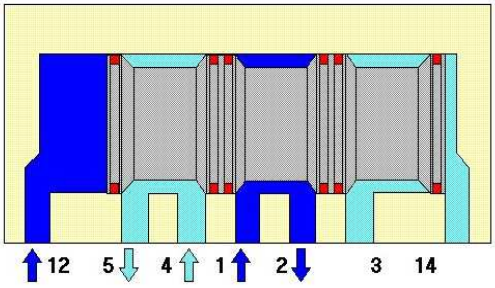
1.4 indirect control of a double acting cylinder via a monostable 5/2 way valve

Basic controls 1.4

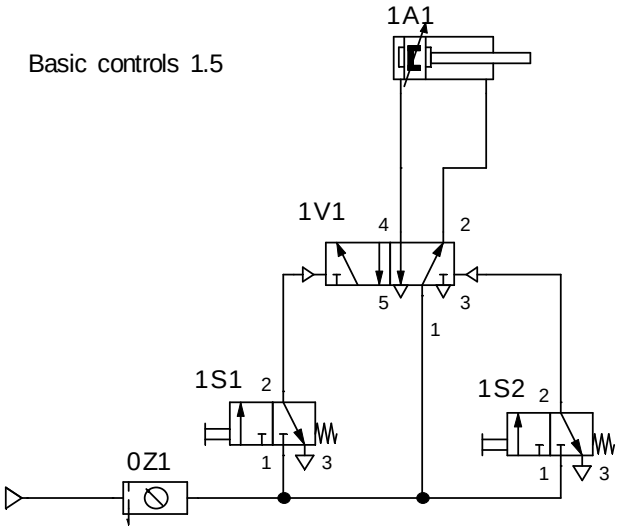


1.5 indirect control of a double acting cylinder by means of a 5/2-way valve, pneumatically actuated at both ends

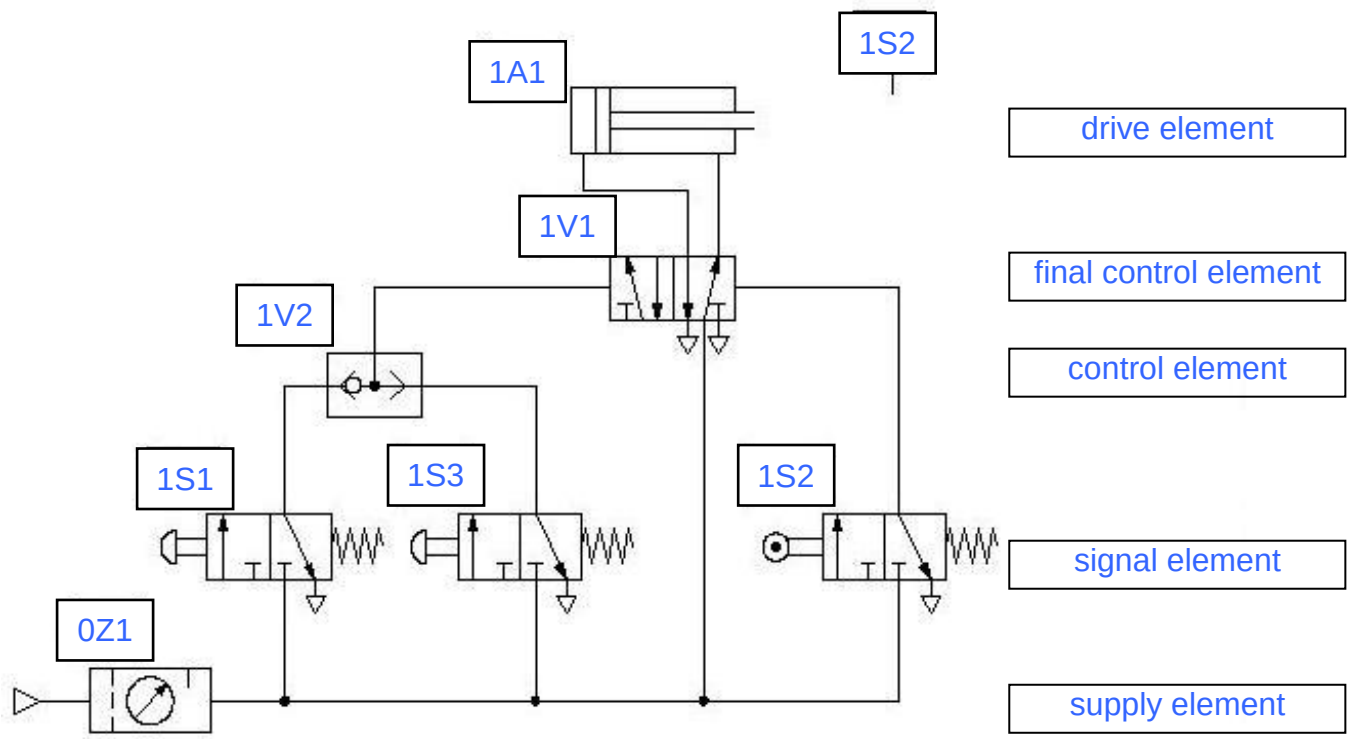




Basic controls 1.5



Item designation	
A	drives
S	signal
B	proximity sensor
V	valves
Z	all other parts



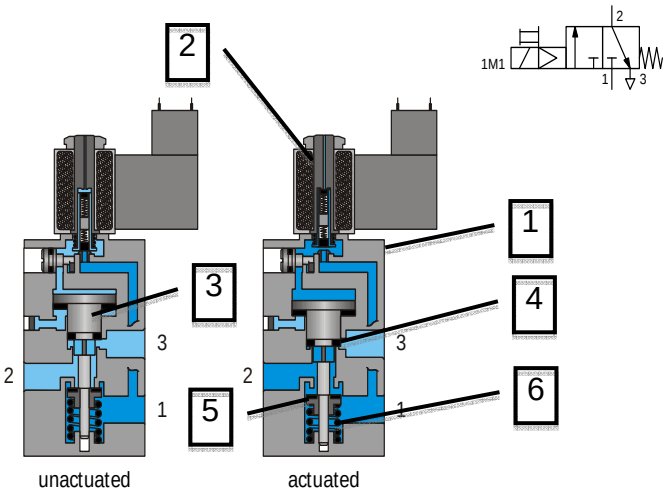
Designations for connections

Pneumatics	*Connection*	*Older pneumatics or hydraulics*
1	inflow, pessure port	P
2 ; 4	working port	A ; B
3 ; 5	exhaust port, tank	R ; S
12 ; 14	control port	X ; Y

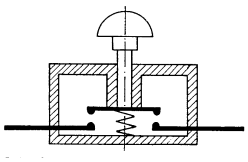
Electro-pneumatic basic controls

2.1 Direct control of a single acting cylinder

3/2-way solenoid valve



Pushbutton, normally open contacts

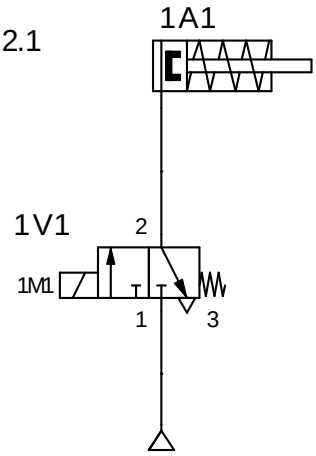


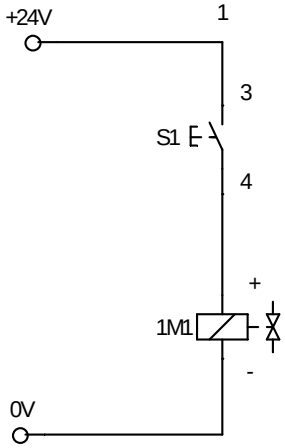
Name the parts of the solenoid valve

1	case
2	coil
3	pistol
4	Gasket 2 to 3
5	Gasket 1 to 2
6	spring

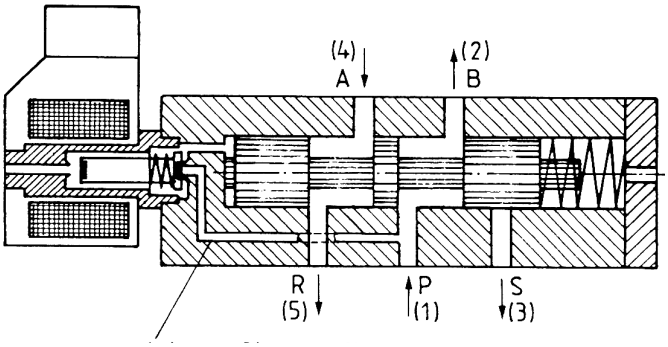
Fill in the numbers of the contacts
for the pushbutton normally open (n. o.).

Basic controls 2.1





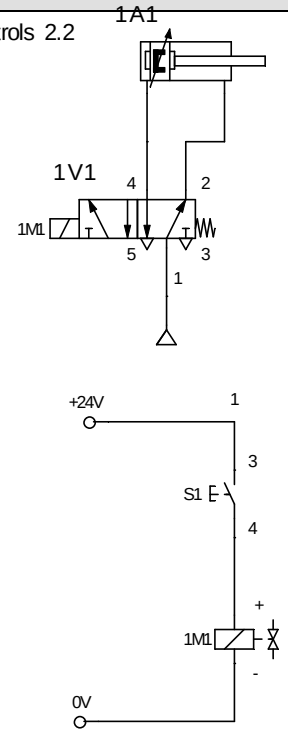
2.2 direct control of a double acting cylinder



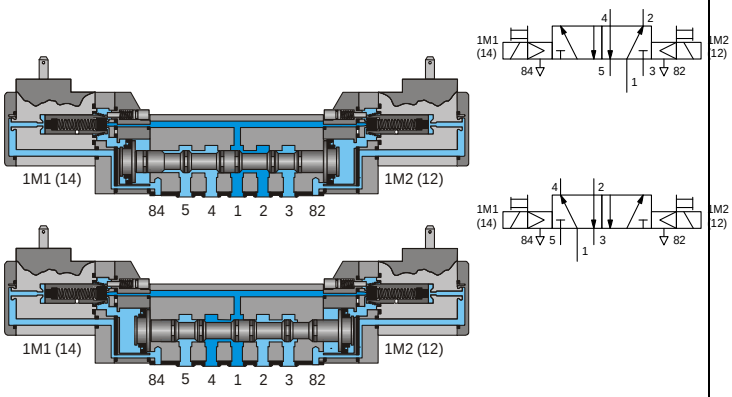
Describe the valve:

5/2 way valve
monostable (with spring)
electical controlled
balanced

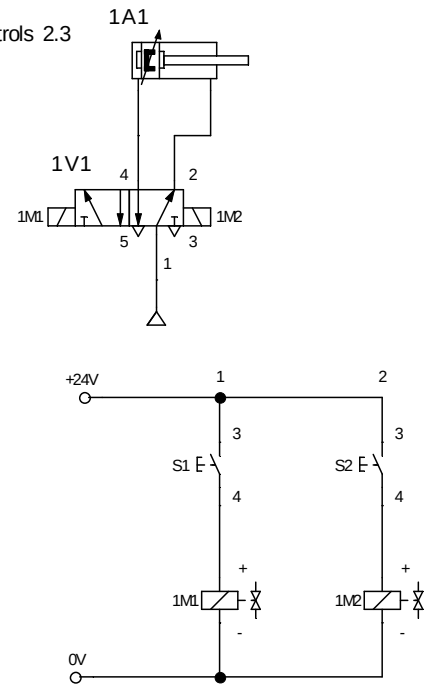
Basic controls 2.2



2.3 Direct control of a double acting cylinder by means of a 5/2-way double solenoid valve



Basic controls 2.3



3.2 Sliding door (WO2)

Learning outcomes

After completing this work order:

You'll be able to describe (1F) the function of the magnetic proximity sensor.

You'll be able to differentiate (2Ca) between AND and OR logic operations.

You'll be able to analyse (4Ca, 4P) the result of the loss of air for your circuit.

You'll be able to carry out (3P) the development and simulation of the circuit for the task.

You'll be able to check and evaluate (5Ca, 5P) your circuit.

Presentation of the problem

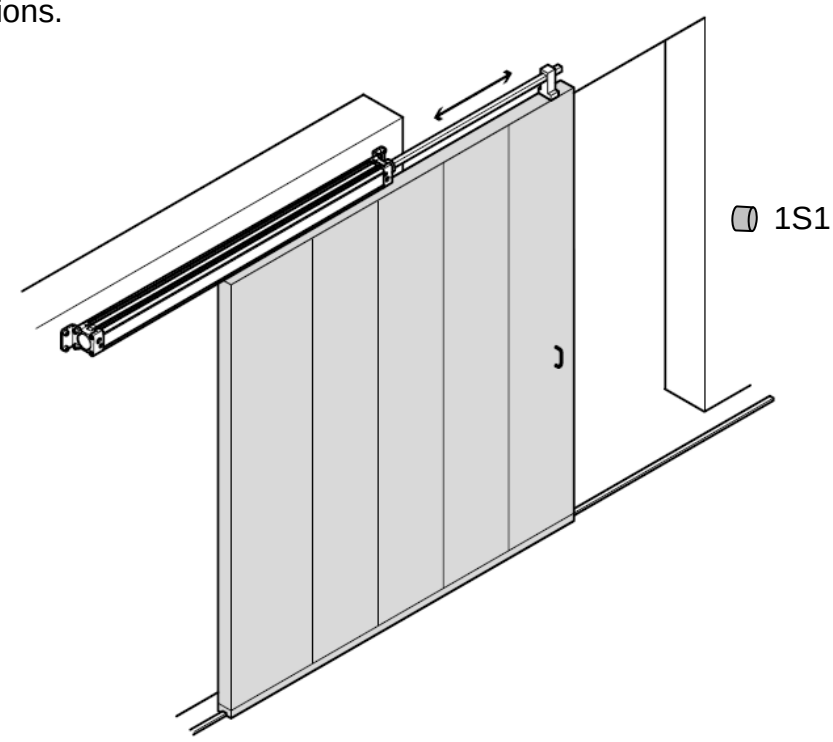
A sliding door between two rooms needs to be opened and closed by using a pushbutton. Only one pushbutton should be located at each side of the door (1S1, 1S2) in order to prevent operator error in case of an emergency.
The process can only be started when the door is in one of its end positions. The Pressure must be limited to 3 bar (300 kPa) for safety reasons (danger of pinching).

Procedure

When the sliding door is in one of its defined end positions, it can be moved to the other end position by pressing the pushbutton. The door can thus be opened and closed.

The opening and closing processes cannot be started as long as the door is not in one of its end positions.

Layout



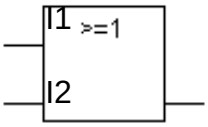
Tasks

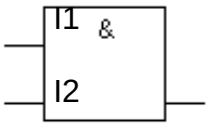
1. Create and simulate the electro-pneumatic circuit diagram for the sliding door's control system with correct description of the components including an equipment list.
2. Set up the control system on your mounting plate.
3. Describe the function of the magnetic proximity sensor 540695. What type of cylinder is therefore needed? For function presentation see: http://reed-switch-info.com/

Reed switch

Additional tasks

4. What happens if compressed air supply fails during advance or return motion?
5. How can the control system be put back into operation, what must be done?
6. Fill in the function/truth table below.

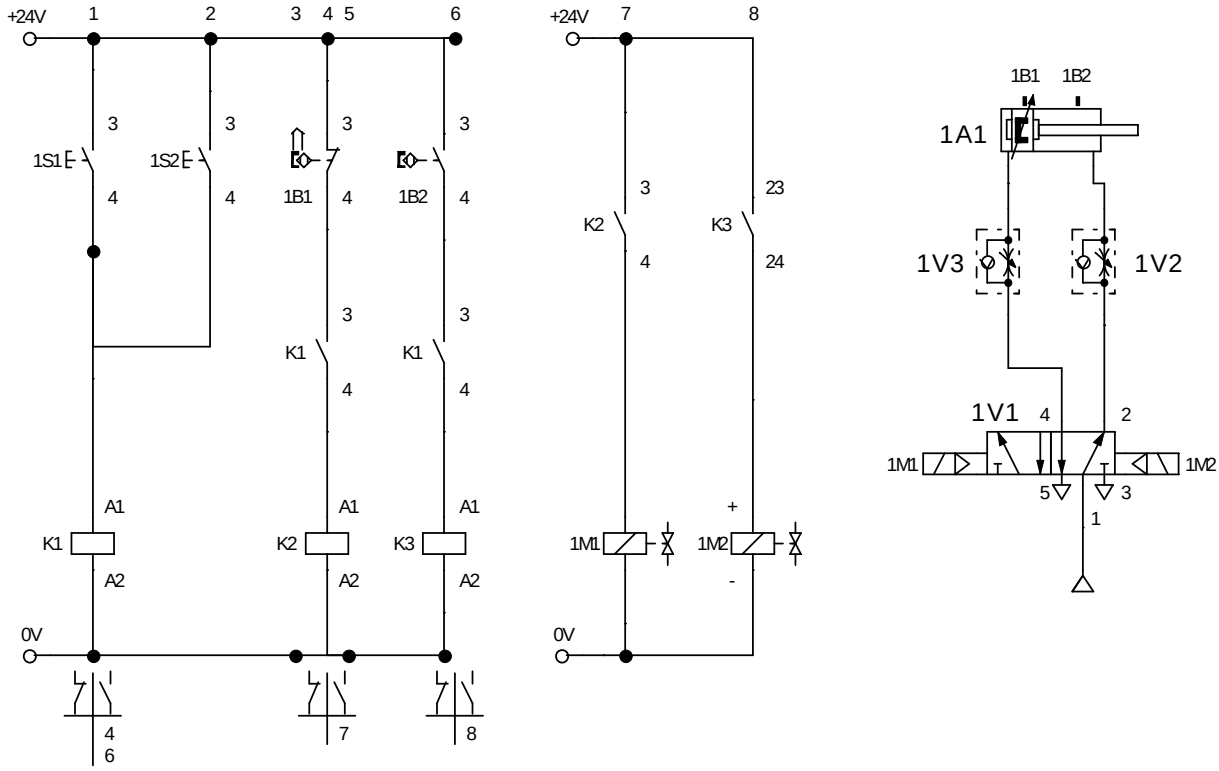
>=1 : OR Logic Operation	Function/truth table				Description of function
	I1	I2	Q		
	0	0			
	0	1			
	1	0			
	1	1			

& : AND Logic Operation	Function/truth table				Description of function
	I1	I2	Q		
	0	0			
	0	1			
	1	0			
	1	1			

Solution

Create and simulate the electro-pneumatic circuit diagram for the sliding door's control system with correct description of the components including an equipment list.

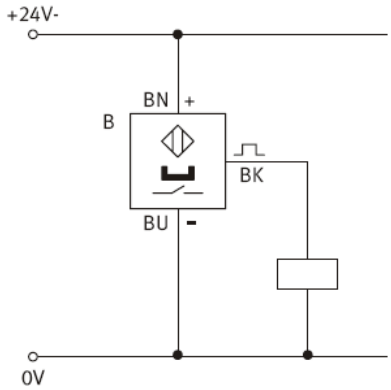
WO2 sliding door



Set up the control system on your mounting plate.

The set up is done on the mounting plate

Describe the function of the magnetic proximity sensor 540695. What type of cylinder is therefore needed? For function presentation see: http://reed-switch-info.com/



The proximity sensor reacts when a magnetic field approaches. It can therefore only be used with cylinder piston with a permanent magnet.

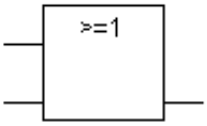
What happens if compressed air supply fails during advance or return motion?

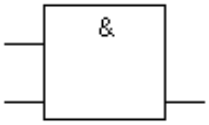
The door remains in its current position.

How can the control system be put back into operation, what must be done?

It must be manually pushed into one of its end-positions in order to restart the control system, because otherwise the start condition is not fulfilled (door is in one of its two end-positions).

Fill in the function/truth table below.

>=1 : OR Logic Operation	Function/truth Table	Description
	I1 | I2 | Q 0 | 0 | 0 0 | 1 | 1 1 | 0 | 1 1 | 1 | 1	*If the signal state of one of one operand is 1, the condition is satisfied.*

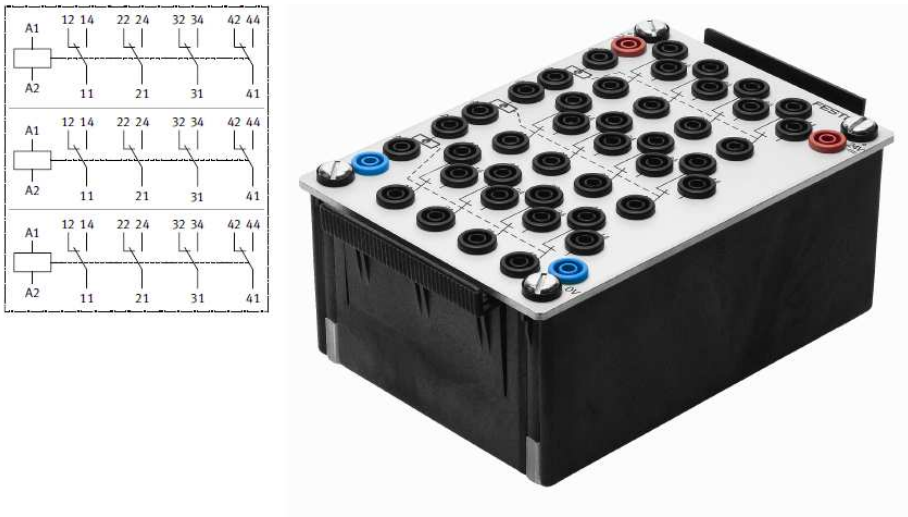
& : AND Logic Operation	Function/truth Table	Description
	I1 | I2 | Q 0 | 0 | 0 0 | 1 | 0 1 | 0 | 0 1 | 1 | 1	*If the signal state of all operands is 1, the condition is satisfied.*

Relays

Tasks

Test the relay:

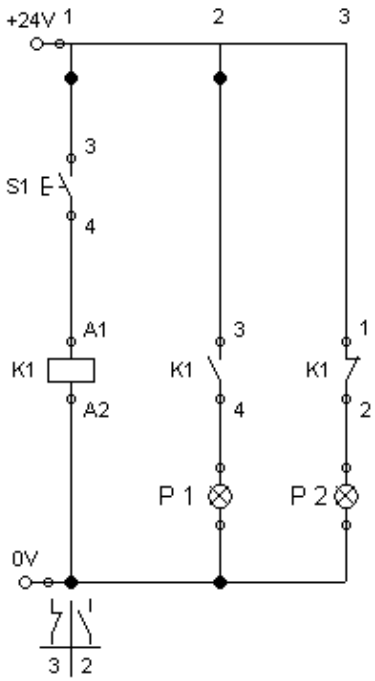
1. Connect a n.o. contact S1 with A1 and A2 of the relay coil (K1)
   Connect a lamp P1 that lights if you operate S1.
   Connect a lamp P2 that goes off if you operate S1.



2. Create and simulate the circuit diagram.
3. Set up the circuit diagram on your mounting plate.
4. Describe the functions of relays in electric circuits.

Solution

2. Create and simulate the circuit diagram.



4. Describe the functions of relays in electric circuits.

Relays can be used to:

Multiply a signal.

Invert a signal from 1 to 0 and vice versa.

Increase a signal

Store a signal

3.3 Roller conveyor (WO3)

Learning outcomes

After completing this work order:

You'll be able to carry out (3P) the correct connection of a proximity sensor in an electric circuit.

You'll be able to understand (2F) the function of the different proximity sensors.

You'll be able to recognize (1F) and apply (3P) the appropriate proximity sensor for the task.

You'll be able to understand (2F) the difference between a 5/2-way single solenoid valve and a 5/2-way double solenoid valve.

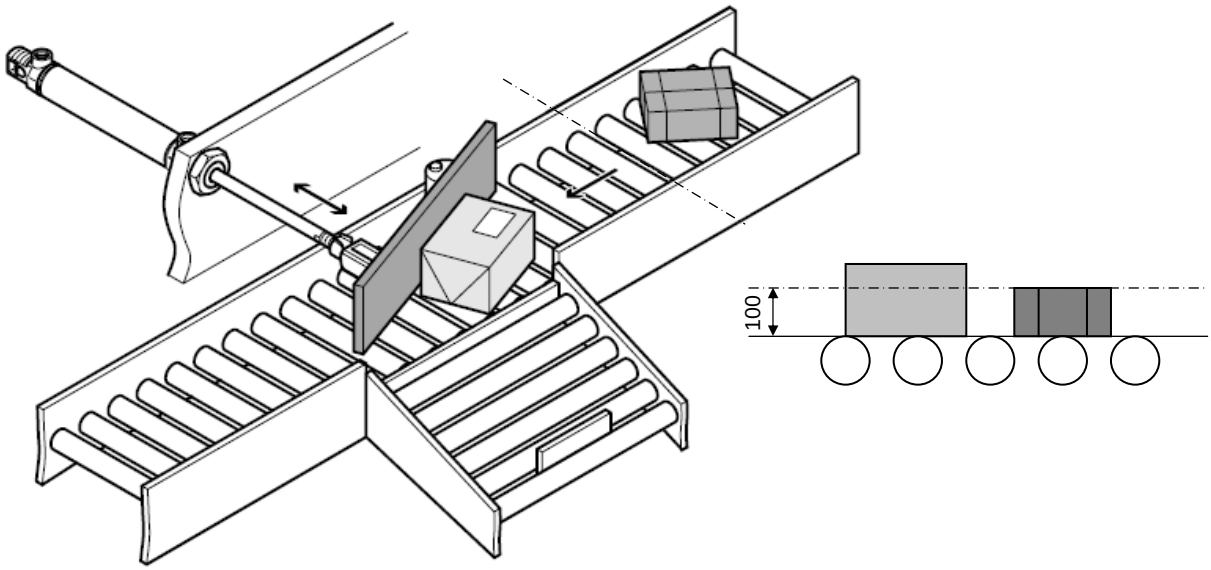
You'll be able to carry out (3P) the development and simulation of the circuit for the task.

You'll be able to check and evaluate (5Ca, 5P) your circuit.

Presentation of the Problem

The roller conveyor transports packages of different heights. If a package is higher than 100mm it should be pushed off the roller conveyor.

Layout



Procedure

If a proximity sensor detects a "high" package and the on-switch is activated the double acting cylinder extends and after having pushed the package off, retracts automatically.

Choose an appropriate proximity sensor. Use a 5/2-way single solenoid valve and a double acting cylinder for the control system.

Tasks

1. Do the information part **proximity sensors** of WO 3.
2. Describe the difference between an inductive and a magnetic proximity sensor!
3. Create and simulate the electro-pneumatic circuit diagram for the roller conveyor control system with correct description of the components including an equipment list.
4. Set up the control system on your mounting plate.
5. Describe the difference in function between a 5/2-way **single** solenoid valve and a 5/2-way **double** solenoid valve.

Solution

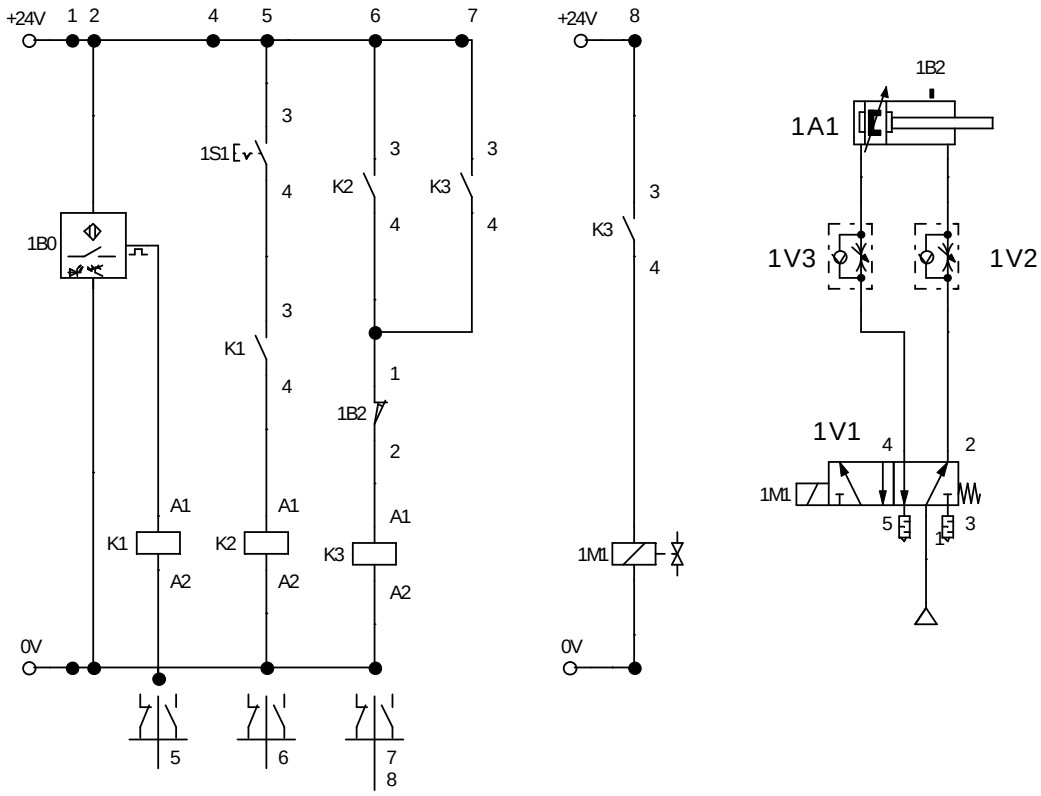
1. Do the information part **proximity switches** of WO 3.

Solution: see WO 3_proximity switches SOL

2. Describe the difference between an inductive and a magnetic proximity sensor!

The inductive sensor reacts if an electrically conductive material approaches. The magnetic field is produced by the sensor.
The magnetic sensor (reed switch) reacts if a magnetic field approaches.

3. Create and simulate the electro-pneumatic circuit diagram for the roller conveyor control system with correct description of the components including an equipment list. WO 3 roller conveyor



4. Set up the control system on your mounting plate.

5. Describe the difference in function between a 5/2-way **single** solenoid valve and a 5/2-way **double** solenoid valve.

*A 5/2-way **single** solenoid valve gets back in its initial position as soon as the signal is gone because of the spring return.*

*A 5/2-way **double** solenoid valve switches and remains in its position when it gets a short signal.*

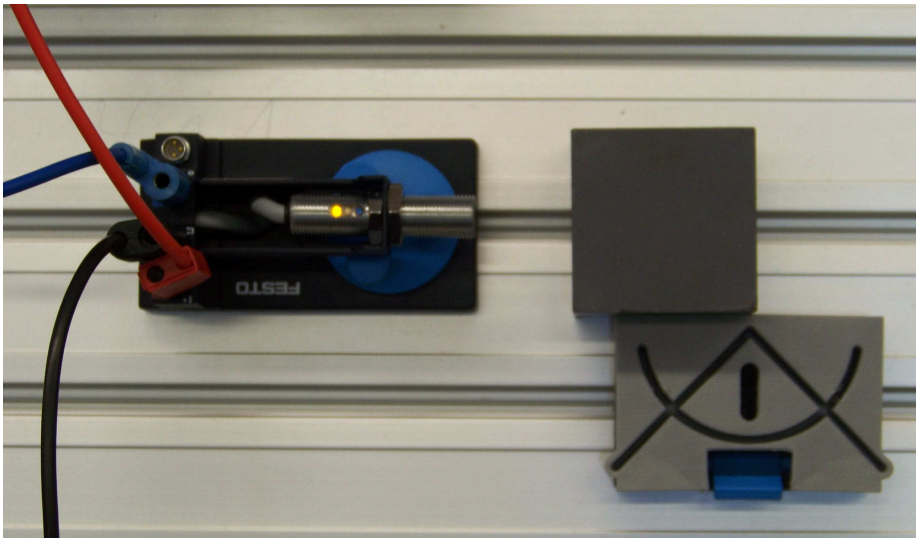
Proximity Sensors

In order to find out how different proximity sensors react to different materials do the following tests.

Equipment

Objects: cubes made of aluminium, grey plastic, transparent plastic

Proximity sensors: inductive, capacitive, optical (see Book of Tables)



Tasks

1. Create and simulate the electric circuit diagram for the proximity sensors.
2. Set up the circuits on your mounting plate.

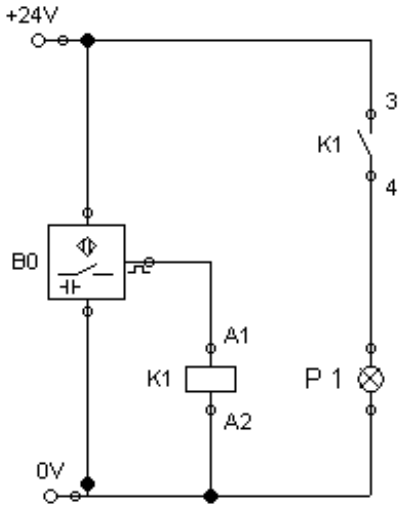
Connect the sensor to a 24 V DC power supply and the output Q1 to a signal lamp P1

Test the 3 proximity switches and fill in the table
(1 = sensor reacts to material; 0 = sensor does not react).

proximity sensor	symbol	material			
		aluminium	black plastic	white plastic	steel
inductive					
optical					
capacitive					

Solution

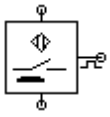
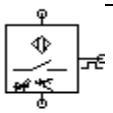
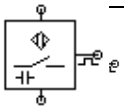
1. Create and simulate the electric circuit diagram for the proximity sensors.



2. Set up the circuits on your mounting plate.

Connect the sensor to a 24 V DC power supply and the output Q1 to a signal lamp P1

3. Test the 3 proximity switches and fill in the table
(1 = sensor reacts to material; 0 = sensor does not react).

proximity sensor	symbol	material			
		aluminium	black plastic	white plastic	steel
Inductive		*1*	*0*	*0*	*1*
optical		*1*	*1*	*1*	*1*
capacitive		*1*	*1*	*1*	*1*

3.4 Vacuum (WO4)

Learning outcomes

After completing this work order:

You'll be able to describe (1F) the function and principle of the vacuum generator.

You'll be able to describe (1F) the function of a pneumatic semi rotary drive.

You'll be able to analyse (4P) the result of the loss of electric power for your circuit.

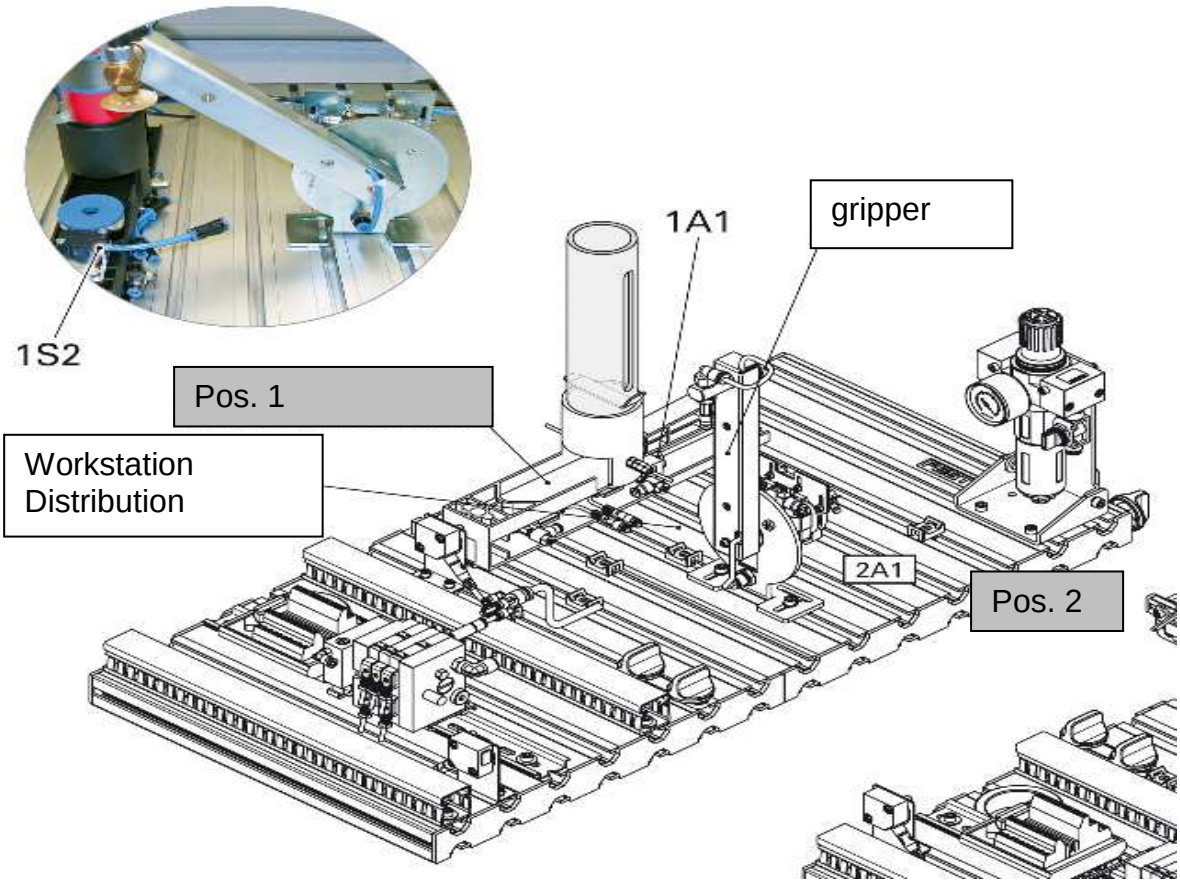
You'll be able to carry out (3P) the development and simulation of the circuit for the task.

You'll be able to check and evaluate (5Ca, 5P) your circuit.

Presentation of the problem

Workpieces shall be transported from the distribution workstation to the next one. A gripper transports the workpiece from position 1 to the next station position 2. The gripper consists of a vacuum generator/suction cup and a pneumatic semi rotary drive.

Layout



Procedure

The gripper moves from position 2 to position 1.

When the gripper is in position 1 and the suction cup holds the workpiece safely by means of a vacuum the semi rotary drive moves back to position 2 and drops the workpiece.

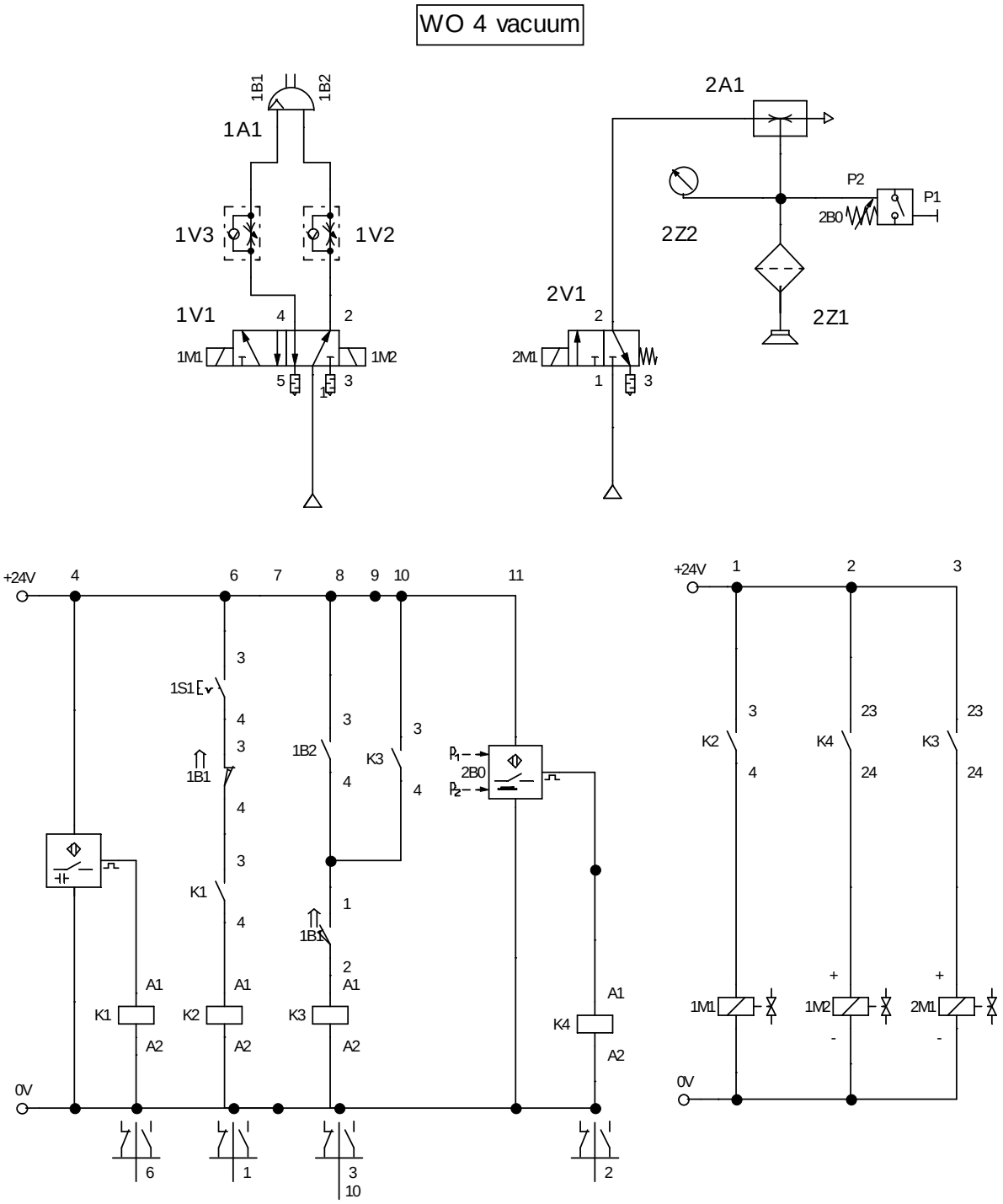
The process is started if the capacitive proximity sensor in Pos. 1 detects the plastic workpiece and the on-switch is operated.

Tasks

1. Check http://youtu.be/zkM9Ir30rw8 to see an example for handling with vacuum.
2. Create and simulate the electro-pneumatic circuit diagram for the vacuum work order with correct description of the components including an equipment list.
3. Set up the control system on your mounting plate.
4. Describe the function of the vacuum generator/suction cup 152891. Find another example which uses the same principle. Check also http://youtu.be/8MvHplOIQCI.
5. Describe the function of a pneumatic semi rotary drive.
6. What happens in the case of an electric power loss during the transport of the work piece?

Solution

1. Check http://youtu.be/zkM9Ir30rw8 to see an example for handling with vacuum.
2. Create and simulate the electro-pneumatic circuit diagram for the vacuum work order with correct description of the components including an equipment list.



3. Set up the control system on your mounting plate.
4. Describe the function of the vacuum generator/suction cup 152891. Find another example which uses the same principle. Check also http://youtu.be/8MvHplOIQCI.

The vacuum generator works on the ejector principle: The velocity of the air that flows through a tube gets higher if the diameter of the tube gets smaller. If you connect another tube in this section the air gets drawn out of it and produces a vacuum. (Skizze)(Example)

5. Describe the function of a pneumatic semi rotary drive.

A semi rotary drive works basically like a double acting cylinder. But instead of a piston there is a rotary vane that turns a drive shaft about 180^0.

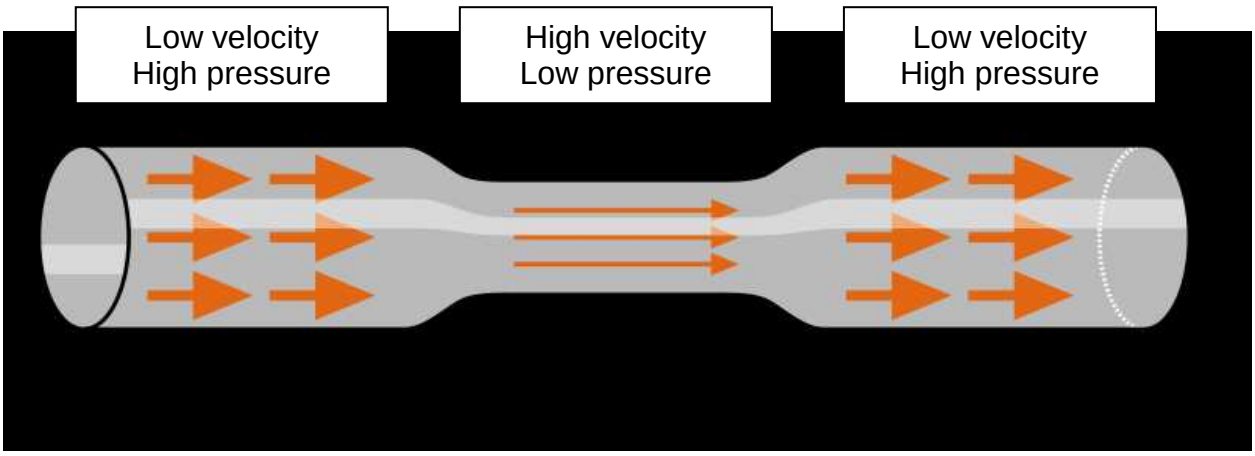
6. What happens in the case of an electric power loss during the transport of the work piece?

The single solenoid 3/2 way valve gets back in initial position. The airflow through the vacuum generator is cut off and the vacuum stops. Therefore the workpiece will fell off the suction cup.

Venturi effect

The **velocity** of the air increases as the cross sectional area decreases.

The **pressure** of the air decreases as the cross sectional area increases.



Venturi effect

In which area of the pipe would you connect the suction cup?

In the high velocity, low pressure area.

3.5 Sawing fixture (WO5)

Learning outcomes:

After completing this work order:

You´ll be able to describe (1F) the function of the pressure switch.

You´ll be able to calculate and select (3Ca) the appropriate cylinder.

You´ll be able to calculate and analyze (4Ca) the air consumption.

You´ll be able to carry out (3P) the development and simulation of the circuit for the task.

You´ll be able to check and evaluate (5Ca, 5P) your circuit.

Presentation of the problem

A wooden board is clamped by means of a single-acting cylinder. The cutting feed with the saw is done by means of a double acting cylinder.

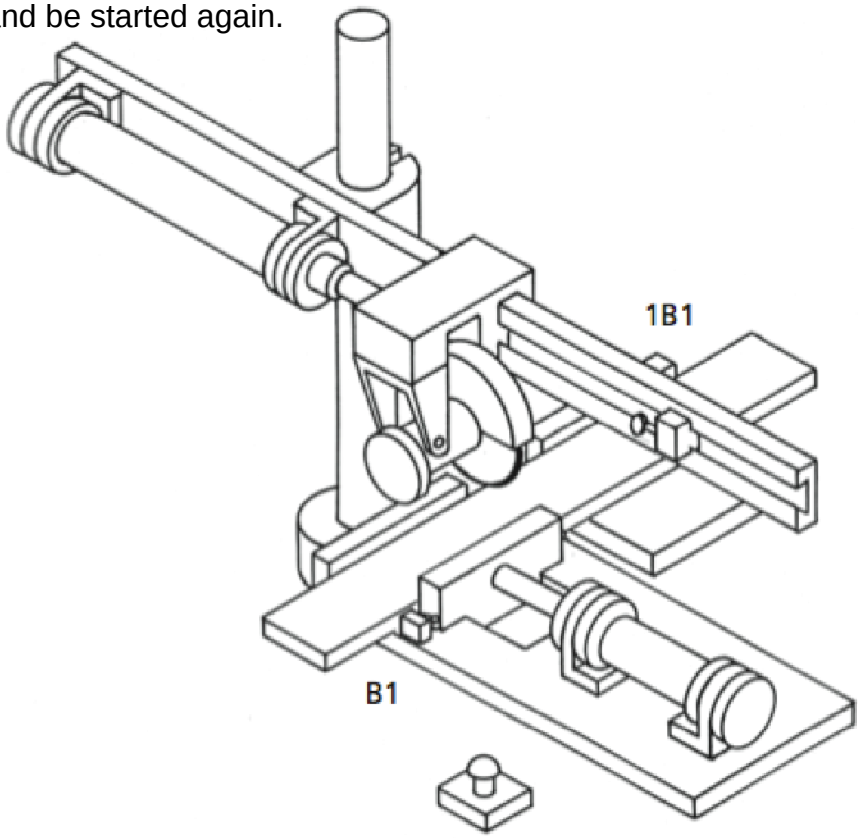
Procedure

First the componentes should be clamped manually by a single-acting cylinder.

The double-acting cylinder can only extend after reaching a pressure of 4.5 bar at the single acting cylinder and by pushing the two handbuttons. (Note: not a two-hand safety control)

If the pressure decreases the cylinder must retract. After reaching the end position the saw has to go back and be started again.

Layout:



Calculation

The single-acting cylinder needs a force of **1000 N** by an operation pressure of **6 bar**. The stroke length is **125 mm**.

The efficiency is **88 %**.

The double-acting cylinder needs a force of **700 N** by a operation pressure of **6 bar**. The stroke length is **300 mm**. The efficiency is **93 %**.

1. Chose the right cylinders with the Festo datasheet. Check the result with a calculation!
   (Result single-acting: 50mm; double acting: 40mm)
2. Calculate the air consumption of the double-acting cylinder if it works 6 times per minute forward and backward. (Result: 31.7 l/min)
3. How much more air is consumed if you use a 50 mm double-acting cylinder instead of a 40 mm.
   (Result: 49.7 l/min)
4. Calculate the difference in costs for one hour of operating. (1m³ compressed air costs 0.025 €)
   (Result: 40mm => 0.0475 €/h; 50mm => 0.0725 €/h)

Task

1. Create and simulate the electro-pneumatic circuit diagram for the sawing fixture with correct description of the components including an equipment list.
2. Build the construction according to your Documents and test the function.
3. Describe the function of the pressure switch.

Solution for calculation

The single-acting cylinder needs a force of **1000 N** by an operation pressure of **6 bar**. The stroke length is **125 mm**.

The efficiency is **88 %**.

The double-acting cylinder needs a force of **700 N** by a operation pressure of **6 bar**. The stroke length is **300 mm**. The efficiency is **93 %**.

1. Choose the right cylinders with the Festo datasheet. Check the result with a calculation! (Result single-acting: 50mm; double acting: 40mm)

$$F = p_e \bullet A \bullet \eta \rightarrow A = \frac{F}{p_e \bullet \eta} = \frac{1000Ncm^2}{60N \bullet 0.88} = 18.94cm^2$$

$$A = \frac{D^2 \bullet \pi}{4} \rightarrow D = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4 \bullet 18.94cm^2}{\pi}} = 4.91cm \approx 50mm$$

$$F = p_e \bullet A \bullet \eta \rightarrow A = \frac{F}{p_e \bullet \eta} = \frac{700Ncm^2}{60N \bullet 0.93} = 12.54cm^2$$

$$A = \frac{D^2 \bullet \pi}{4} \rightarrow D = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4 \bullet 12.96cm^2}{\pi}} = 4.00cm \approx 40mm$$

2. Calculate the air consumption of the double-acting cylinder if it works 6 times per minute forward and backward. (Result: 31,7 l/min)

$$Q = 2 \bullet A \bullet s \bullet n \bullet \frac{p_e + p_{amb}}{p_{amb}} = 2 \bullet 0.1256dm^2 \bullet 3dm \bullet \frac{6}{\min} \bullet \frac{6+1}{1} = 31.65\frac{dm^3}{\min} = 31.7\frac{l}{\min}$$

$$A = \frac{D^2 \bullet \pi}{4} = \frac{0.4^2 dm^2 \bullet \pi}{4} = 0.1256dm^3$$

3. How much more air is consumed if you use a 50 mm double-acting cylinder instead of a 40 mm.

$$Q = 2 \bullet A \bullet s \bullet n \bullet \frac{p_e + p_{amb}}{p_{amb}} = 2 \bullet 0.1963dm^2 \bullet 3dm \bullet \frac{6}{\min} \bullet \frac{6+1}{1} = 49.47\frac{dm^3}{\min} = 49.5\frac{l}{\min}$$

$$A = \frac{D^2 \bullet \pi}{4} = \frac{0.5^2 dm^2 \bullet \pi}{4} = 0.1963dm^3$$

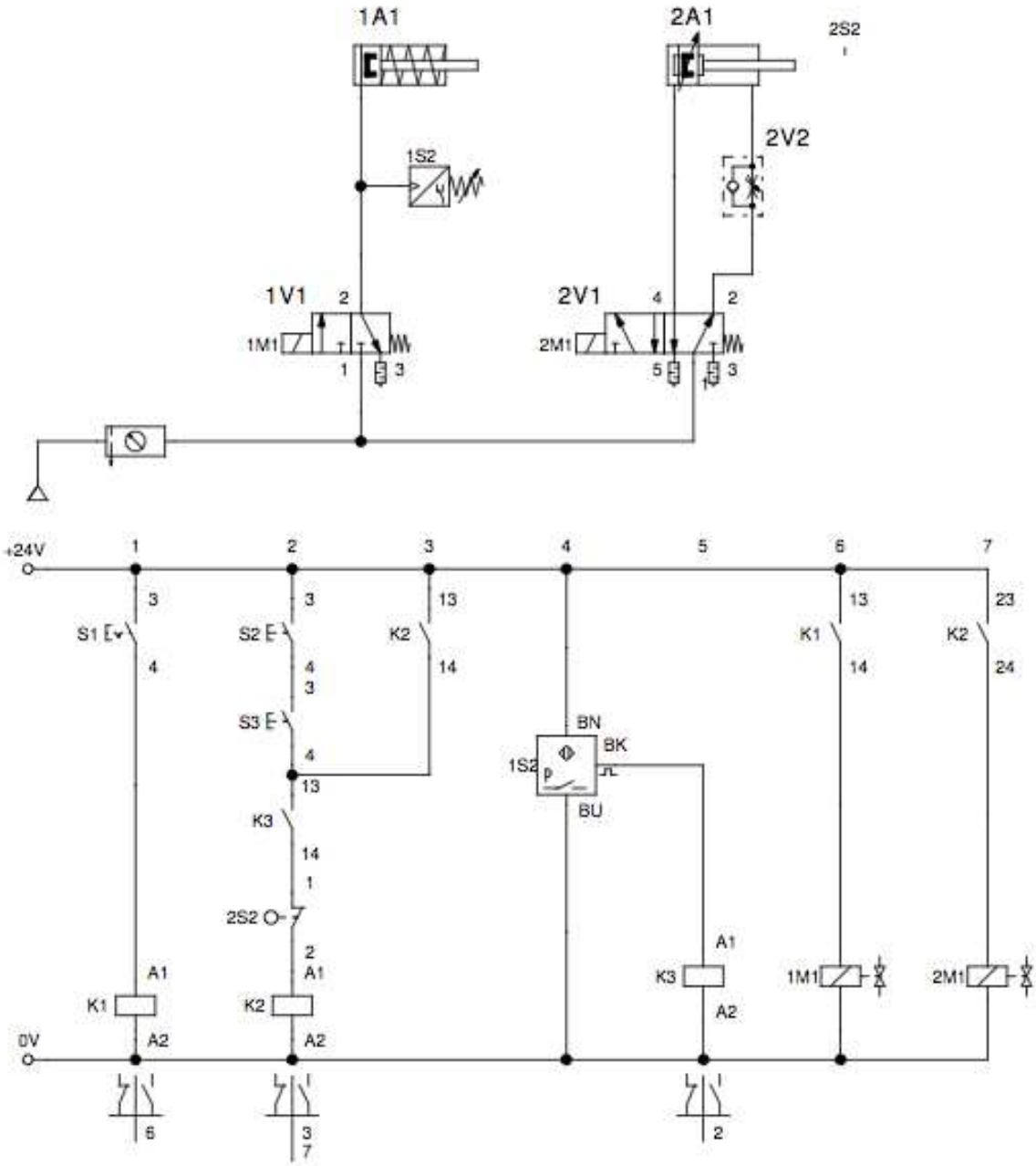
4. Calculate the difference in costs for one hour of operating. (1m³ compressed air costs 0.025 €)

$$Q_{40mm/h} = 31.7\frac{l}{\min} \bullet 60\frac{\min}{h} = 1902\frac{l}{h} = 1.9\frac{m^3}{h} \qquad €/hour = 1.9\frac{m^3}{h} \bullet 0.025\frac{€}{m^3} = 0.0475\frac{€}{h}$$

$$Q_{50mm/h} = 49.5\frac{l}{\min} \bullet 60\frac{\min}{h} = 2970\frac{l}{h} = 2.9\frac{m^3}{h} \qquad €/hour = 2.9\frac{m^3}{h} \bullet 0.025\frac{€}{m^3} = 0.0725\frac{€}{h}$$

Solution

1. Create and simulate the electro-pneumatic circuit diagram for the sawing fixture with correct description of the components including an equipment list.



2. Build the construction according to your Documents and test the function.
3. Describe the function of the pressure switch.

Pressure switches are used in order to generate an electrical output signal when a specified pressure is reached.

Important settings of the SMC pressure switch

F0	**choose pressure unit**		
	push (long)	S	
	adjust **F0** with	△ ▽	
	confirm with	S	
	adjust unit **bar** with	△ ▽	
	confirm (long) with	S	
P1	**adjust switching pressure**		
	push (short)	S	**P1** appears
	adjust pressure with	△ ▽	
	confirm with	S	
F1	**adjust vacuum**		
	push (long)	S	
	adjust **F1** with	△ ▽	
	confirm with	S	**HYS** appears
	confirm with	S	**1_P** appears
	confirm with	S	
	adjust pressure with	△	e.g. - 0,3 bar
	confirm (long) with	S	
F99	normal position (reset)		
	push (long)	S	
	adjust F99 with	△ ▽	
	confirm with	S	
	adjust "on" with	△ ▽	
	push	S + ▽	for 5s => F99 appears
	confirm (long) with	S	
	Note: The pressure unit must be adjusted again!		

3.6 Stamping device (WO6)

Learning outcomes:

After completing this work order:

You'll be able to use (3Ca) the correct item designation.

You'll be able to choose (3Ca; 3P) a suitable proximity sensor

You'll be able to understand (2Ca) and develop (3P) a sequence chain.

You'll be able to carry out (3P) the development and simulation of the circuit for the task.

You'll be able to check and evaluate (5Ca, 5P) your circuit.

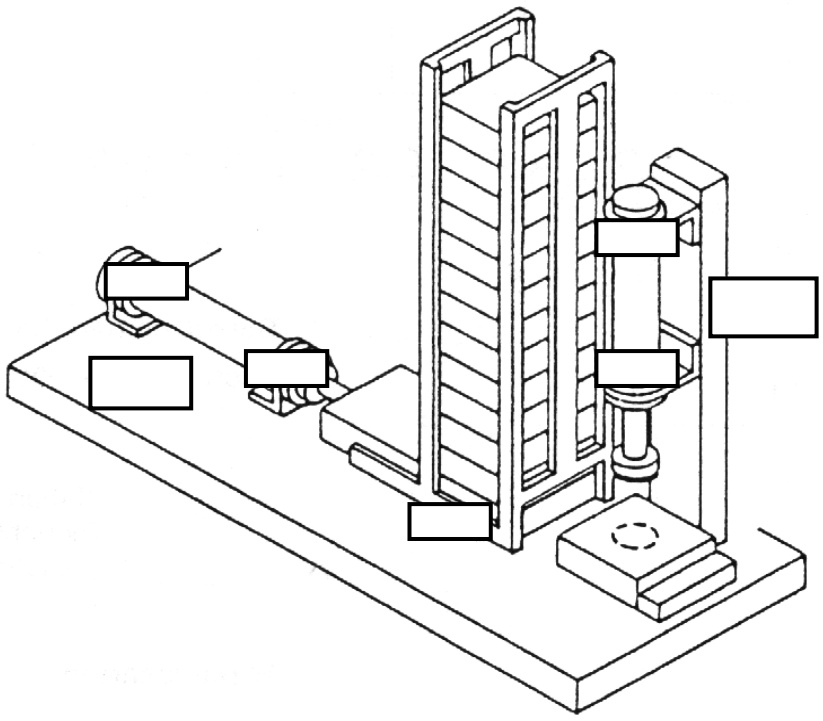
Presentation of the Problem

Aluminium workpieces should be marked in a stamping device.

Procedure

The operation is started by pressing the Start button, when the cylinder 1A1 is in the retracted position and the magazine is filled with workpieces.
The cylinder 1A1 pushes the workpieces from the magazine stack and clamps it to a stop.
The cylinder 2A1 moves down the stamp. After the stamping process the cylinder 2A1 goes back into the starting position. In the end the cylinder 1A1 releases the workpiece, which can be possibly removed by hand.

Layout



Tasks

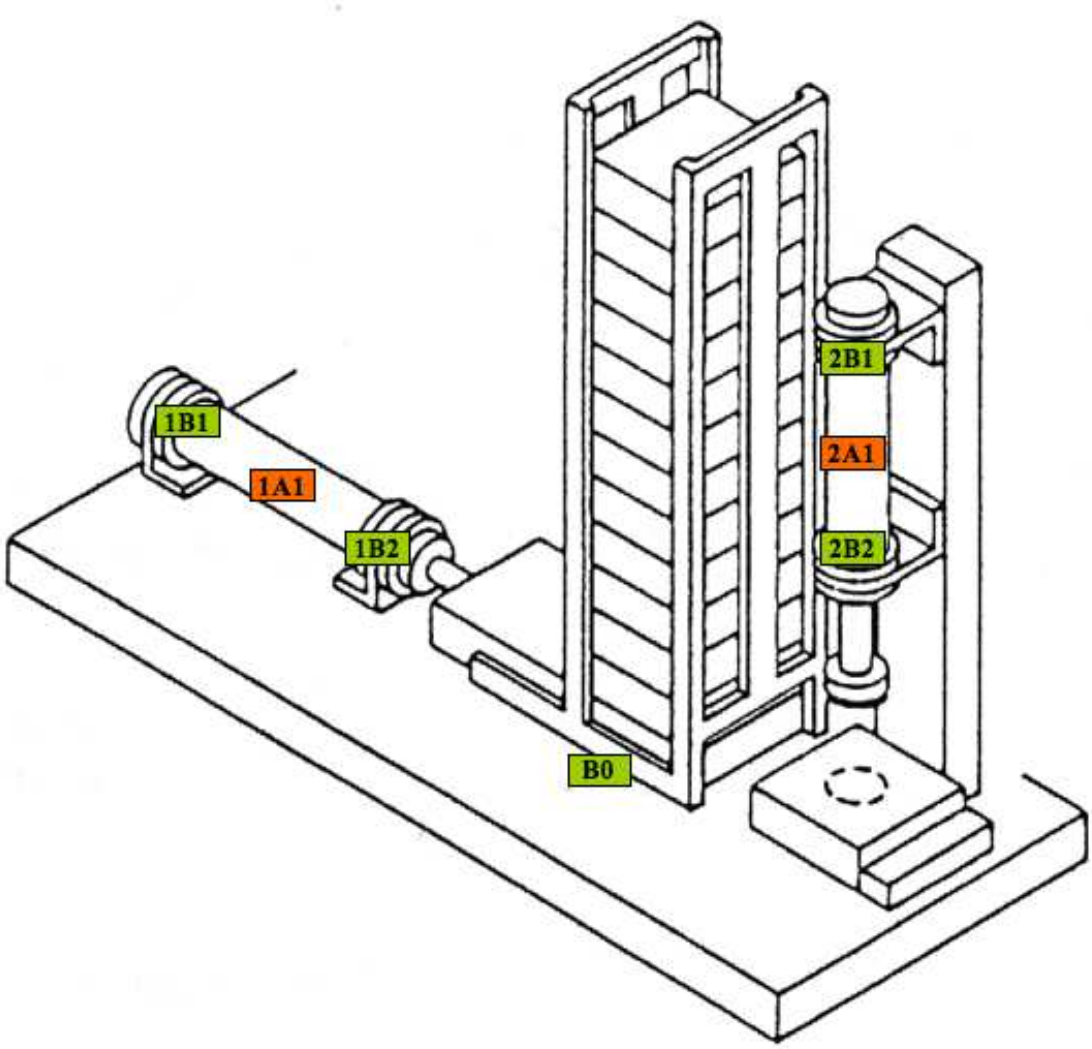
Create an electro-pneumatic solution

To solve this task, follow these steps:

Fill in the correct item designation (Figure above).	
Choose a suitable proximity sensor for the magazine query.	
Study the information for sequence chain for the electro-pneumatic solution.	
Draw and simulate your circuit including a equipment list.	
Construction: With your schematics (from FluidSIM) build on an electro-pneumatic solution.	

Solution

1. Fill in the correct item designation (Figure above).

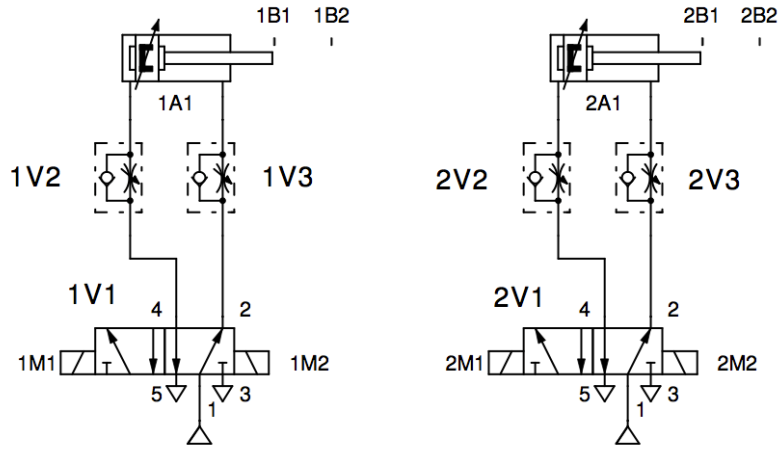


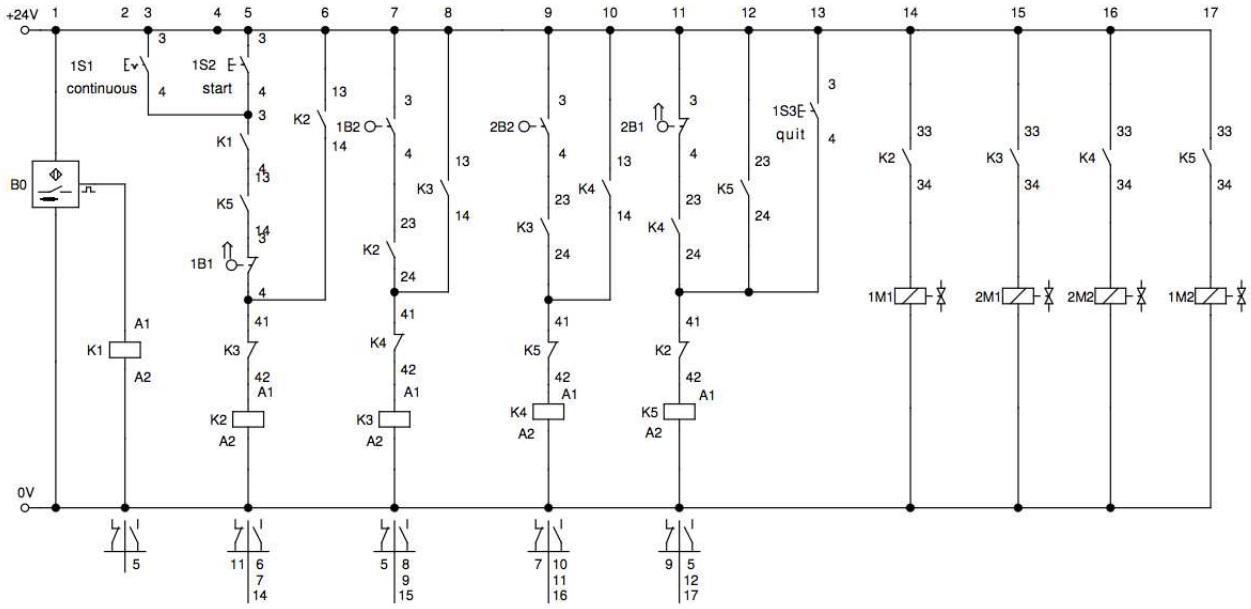
2. Choose a suitable proximity sensor for the magazine query.

Optical proximity sensor, capacitive proximity sensor, inductive proximity sensor

Our solution: inductive proximity sensor (because it works with electric conductive material like aluminium, it would not work with plastic)

4. Draw and simulate your circuit including a equipment list.





Sequence chain

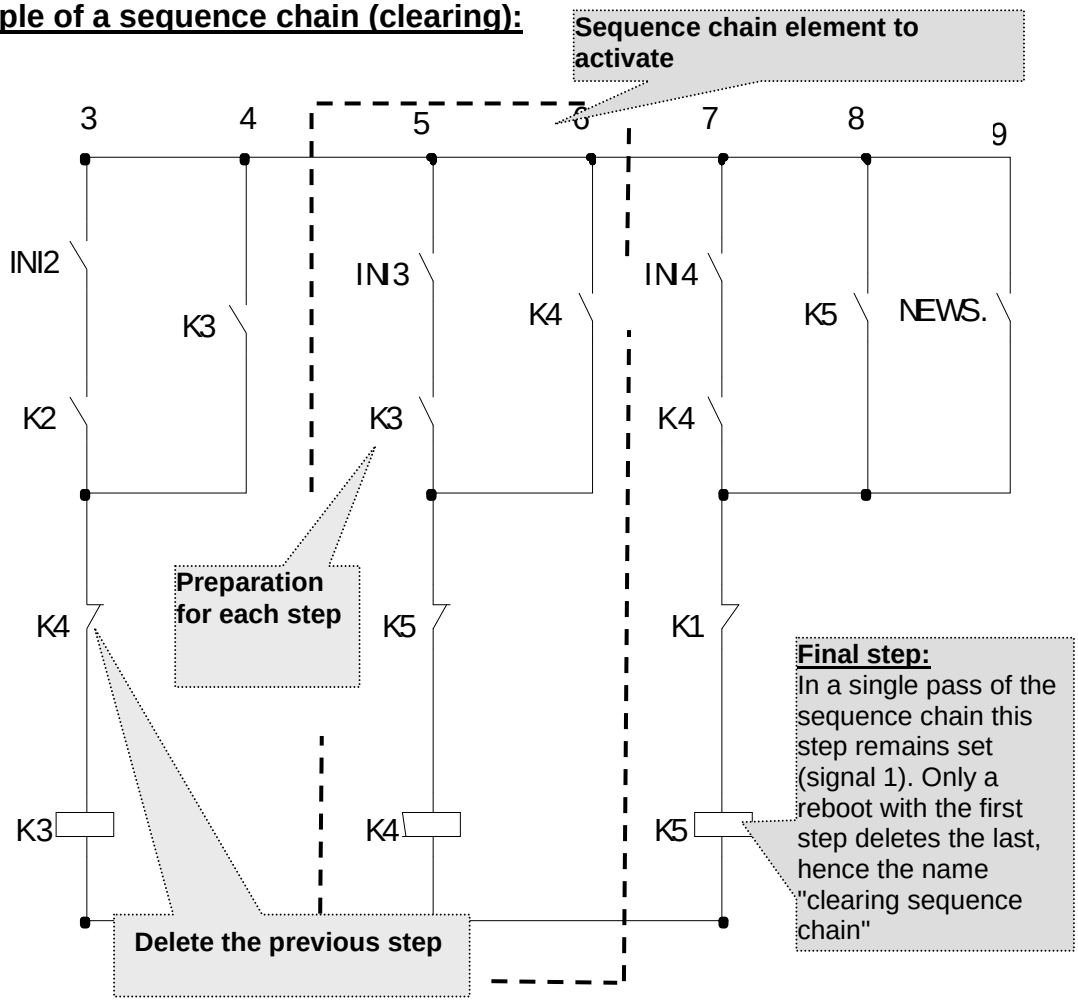
Sequence chains can avoid the problem signal overlap. Extensive tasks with more than two actuators can be planned and carried out easily and safely. Sequence chain controls are therefore a suitable solution for complex automation tasks and frequently used as an industrial standard.

Principle of a sequence chain:

Apply the following **rules for the sequence chain control**:

- Each end position of an actuator operates a signal element (e. g. limit switch).
- Each active step must be provided with a self holding.
- The next step of a sequence chain is only possible, if the previous step has been executed (K3 in path 5).
- The now active step resets the previous step (Normally closed contact K4 in path 3).
- During execution the last step prepares the first step (the first step of the sequence chain would need a normally closed contact of K5). In case of a complete new start of the sequence chain there is no last step that prepares the first one. Therefore the first step has to be prepared by an additional signal element (instead of the normally closed contact of K5 by the NEWS. button in path 9).

Example of a sequence chain (clearing):



Glossary

According to work orders

English	Deutsch
Producing compressed air	
Compressed air	Druckluft
Prepared air	Aufbereitete Luft
Incoming air	Zuluft
Exhaust air	Abluft
Condensate line	Kondensatleitung
Valve	Ventil
Rotare screw compressor	Schraubenverdichter
Compressed air reservoir	Druckkessel
Refrigerated air dryer	Kältetrockner
Oil water separator	Öl Wasser Abscheider
Air filter	Luftfilter
Pressure Regulator	Druckminderer
Work instructions and safety precautions	
Safety precautions	Sicherheitshinweise
Work instructions	Arbeitshinweise
Voltage	Spannung
Safety plug	Sicherheitsstecker
Limit switch	Grenztaster
Troubleshooting	Fehlersuche
Tubings	Schläuche
Push in connector	Steckverbindung
Release ring	Lösungsring

WO 1 Pneumatic basic controls	
Actuation	Betätigungsart
Single-acting cylinder	Einfachwirkender Zylinder
Double-acting cylinder	Doppeltwirkender Zylinder
Way valve	Wegeventil
Pneumatically actuated	pneumatisch betätigt
monostable	monostabil
WO 2 Sliding door	
Sliding door	Schiebetür
Pushbutton	Taster
Switch	Schalter
Normally open (NO) contacts	Öffner
Normally closed (NC) contacts	Schließer
Change over contacts	Wechsler
Reed contact	Reed Kontakt (magnetisch betätigter Kontakt)
Relay	Relais
Coil	Spule
Return spring	Rückholfeder
to apply	anlegen
to remove	wegnehmen
to pinch	einklemmen
WO 3 Roller conveyor	
Roller conveyor	Rollenbahn
Proximity sensor	Näherungsschalter
to extend	ausfahren
to retract	einfahren
optical	optisch
inductive	induktiv
capacitive	kapazitiv

WO 4 Vacuum	
Vacuum generator	Vakuumgenerator
Suction cup	Vakuumsauger
Distribution workstation	Station verteilen
gripper	Greifer
Semi rotary drive	Schwenkantrieb
WO 5 Sawing fixture	
Two-hand safety control	Zweihandsicherheit
Force	Kraft
WO 6 Stamping device	
magazine query	Magazin Abfrage
sequence chain	Schrittkette
to overlap	überschneiden
interrogate	abfragen
presuppose	voraussetzen
catch	hier: *Selbsthaltung*
item designation	Betriebsmittelkennzeichnung

Test

Learning outcomes:

After completing this work order:

You´ll be able to describe (1F) the function of the magnetic proximity sensor.

You´ll be able to understand (2F) the funktion of the different proximity sensors.

You'll be able to understand (2F) the difference between a 5/2-way single solenoid valve and a 5/2-way double solenoid valve.

You'll be able to describe (1F) the function and principle of the vacuum generator.

You´ll be able to calculate and select (3Ca) the appropriat cylinder.

You´ll be able to calculate and analyze (4Ca) the air consumption.

You´ll be able to argue (5Ca) economical aspects

1. Describe the function of a magnetic proximity sensor. What type of cylinder is therefore needed? (2p)

_____

_____

_____

2. Which materials can be detected with an **inductive** proximity sensor! (1p)

_____

_____

3. Which materials can be detected with a **capacitive** proximity sensor! (1p)

_____

_____

4. Describe the difference in function between a 5/2-way **single** solenoid valve and a 5/2-way **double** solenoid valve in case of an electric power outage. (2p)

_____

_____

_____

5. Describe the function of the vacuum generator/suction cup (sketch). (3p)

_____

_____

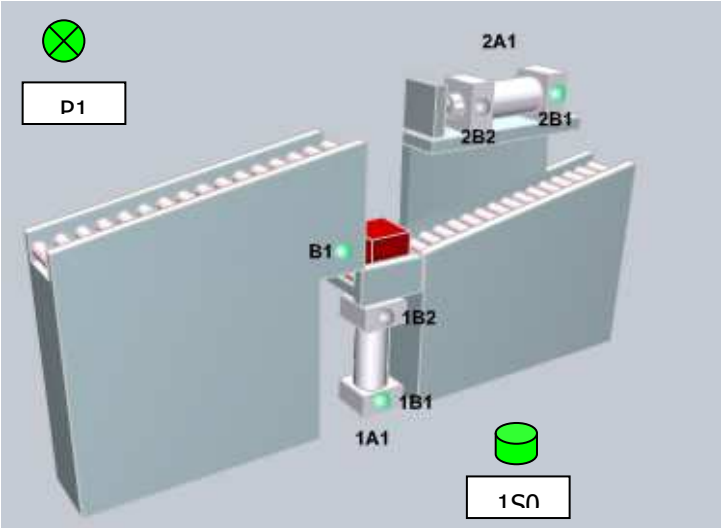
_____

_____

6. Calculation

Cardboard box lifter

The automatic system lifts cardboard boxes.



Calculation:

a) Choose a cylinder 1A1 with a stroke length of 300mm for a parcel of 20 kg, a pressure of 6 bars and an efficiency factor of 0.88. (2p)

b) Calculate the costs for 1 day (8 hours) if 10 parcels per minute are proceed. Cylinder 2A1 has the same diameter than 1A1 and a stroke length of 200mm. 1 m^3 of air costs 0.50 €. (2p)

c) Because of the rising energy prices the controller of your company asks, if there is a possibility to save air and costs. Do you have an idea of improvement? (2 Bonuspoints)

Solution Test

1. Describe the function of a magnetic proximity sensor. What type of cylinder is therefore needed? (2p)

*A proximity **sensor** reacts when a magnetic field approaches. It can therefore only be used with a cylinder pistons that has a permanent magnet. (WO 2)*

2. Which materials can be detected with an **inductive** proximity sensor! (1p)

The inductive sensor reacts if an electrically conductive material approaches.

3. Which materials can be detected with a **capacitive** proximity sensor! (1p)

The capacitive sensor reacts to all material. (WO 3)

4. Describe the difference in function between a 5/2-way **single** solenoid valve and 5/2-way **double** solenoid valve. (2p)

A 5/2-way single solenoid valve gets back in its initial position as soon as the signal is gone because of the spring return.

*A 5/2-way **double** solenoid valve switches and remains in its position.*

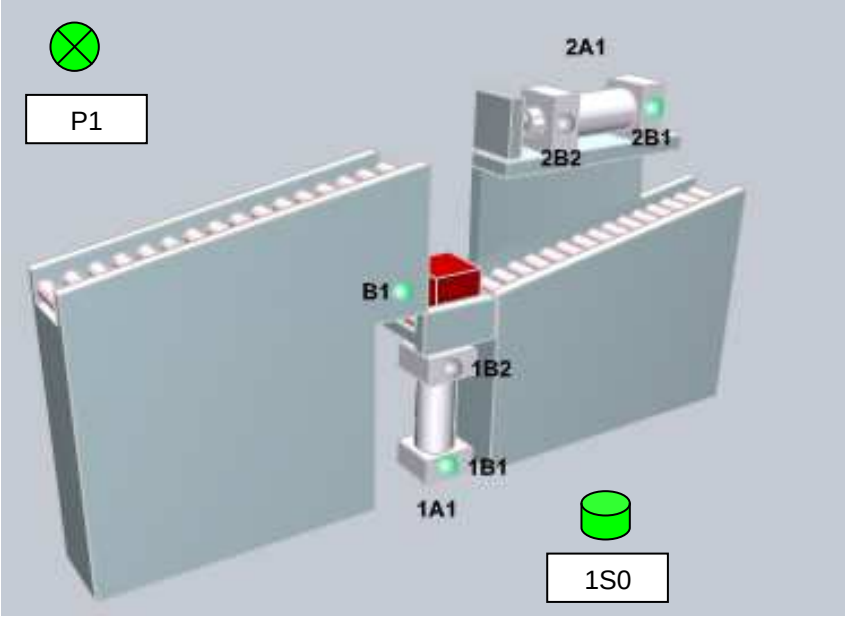
5. Describe the function of the vacuum generator/suction cup (sketch). (3p)

A vacuum generator works on the basis of the ejector principle. Because of the reduction of the diameter the velocity of the air gets higher and the pressure gets lower. The vacuum cup is connected to the reduced section where the pressure is lower and air is drawn in the vacuum cup. (WO 4)

6. Calculation

Cardboard box lifter

The automatic system lifts cardboard boxes.



Calculation:

a) Choose a cylinder 1A1 with a stroke length of 300mm for a parcel of 20 kg, a pressure of 6 bars and an efficiency factor of 0.88.

$$F = p_e \bullet A \bullet \eta \rightarrow A = \frac{F}{p_e \bullet \eta} = \frac{200Ncm^2}{60N \bullet 0.88} = 3.79cm^2 \qquad (v)$$

$$A = \frac{D^2 \bullet \pi}{4} \rightarrow D = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4 \bullet 3.79cm^2}{\pi}} = 2.20cm \approx 22mm \qquad (v)$$

Next possible size d = 25mm.

b) Calculate the costs for 1 day (8 hours) if 10 parcels per minute are proceeded. Cylinder 2A1 has the same diameter than 1A1 and a stroke length of 200mm. 1 m³ of air costs 0.50 €.

1A1, 300mm:

$$A = \frac{D^2 \bullet \pi}{4} = \frac{0.25^2 dm^2 \bullet \pi}{4} = 0.0491dm^2 \qquad (v)$$

$$Q_{1A1} = 2 \bullet A \bullet s \bullet n \bullet \frac{p_e + p_{amb}}{p_{amb}} = 2 \bullet 0{,}0491dm^2 \bullet 3dm \bullet \frac{10}{\min} \bullet \frac{6+1}{1} = 20.6\frac{dm^3}{\min} = 20.6\frac{l}{\min} \qquad (v)$$

2A1, 200mm:

$$A = \frac{D^2 \bullet \pi}{4} = \frac{0.25^2 dm^2 \bullet \pi}{4} = 0.0491dm^2$$

$$Q_{2A1} = 2 \bullet A \bullet s \bullet n \bullet \frac{p_e + p_{amb}}{p_{amb}} = 2 \bullet 0{,}0491dm^2 \bullet 2dm \bullet \frac{10}{\min} \bullet \frac{6+1}{1} = 13.8\frac{dm^3}{\min} = 13.8\frac{l}{\min} \qquad (v)$$

$$Q_{8h} = (Q_{1A1} + Q_{2A1}) \bullet 60\frac{\min}{h} \bullet 8\frac{h}{day} = (20.6\frac{l}{\min} + 13.8\frac{l}{\min}) \bullet 60\frac{\min}{h} \bullet 8\frac{h}{day} = 16512l = 16.5m^3$$

Costs per day app. 8.25 € *(v)*

c) Because of the rising energy prices the controller of your company asks, if there is a possibility to save air and costs. Do you have an idea of improvement?

Cylinder 2 A1 does need less force and diameter than 1A1 because it only pushes the parcel horizontally of the roller conveyor. A smaller diameter would also mean less consumption of air. Bonus (v)(v)

Σ15 (17)

Work orders	180-151	150-121	120-91	90-46	45-0
Paper and pencil	15-13	12-10	9-7	6-4	3-0
mark	**1**	**2**	**3**	**4**	**5**

At least 50% are necessary for passing:

work orders **90 points**

paper and pencil test **7.5 points**

Work order company

Electro pneumatic Module

Content

1. Description of Work Assignment

MOVET II Examination Part 1	
Description of work assignment	**Electro pneumatic Module**

1. General

In the examination part 1 you have to complete a complex work assignment.

2. Time limit: 2.5 h

3. Examination documents which must be supplied for every candidate including this work assignment :

- Description of work assignment (page 3/4)
- P reparation sheet (page 5)
- Preparation mounting plate (page 6)
- Drawing of the mechanical unit (page 7)
- Pneumatic circuit (page 8)
- GRAFCET (page 8)
- Electric circuit (page 9)
- Evaluation sheet (page 10)

4. Identification of the examination documents

Enter your name in the specified area. (page 10)

5. Task related interview

During the work assignment the examiner will conduct a task related interview. Answer the questions in a short, professional manner using the proper trade terminology. Demonstrate that you can technically describe the trade specific facts.

6. Description of work assignment

The assembly with control function is a fixture designed to separate individual spacers.
The magazine (pos. 9) feeds the spacers (pos. 16) to the pusher (pos. 5). The movement of the pusher occurs through the double acting cylinder (1A). With every extension stroke one spacer is pushed out of the magazine.

7. Manufacturing process

Your work assignment is to build a completely functional assembly on the prepared mounting plate with all the necessary control functions, according to drawings and other documents. All work safety rules and regulations must be followed at all times. Your assignment comprises the following:

Marking the parts
Assembly of individual components
Wiring
Piping hose system
Adjusting and fine tuning of assembly
Quality control: Check functionality of complete work assignment

Adjustment conditions:

The following adjustment conditions must be fulfilled on the control part of the assembly.

- The extension time and the retraction time of the piston rod must be adjusted according to GRAFCET.
- The piston has a cushioning on both ends.
- During continuous operation, the piston will separate two spacers from the magazine. (GRAFCET)
- All final adjustments must be secured/locked. (knurled nuts must be locked)
- The operating pressure must be set to a minimum of 4 bar.

8. Evaluation

Check your work assignment using the sheet called "Inspection by Apprentice“ (sheet 5 of 5). Decide by yourself when and how your inspection should be conducted. Evaluate if given criteria are fulfilled. Document your decision in the table section of your worksheet.

9. Handing in the documents

Make sure that all your documentation is marked with your name. Hand in your documents to the examination board.

2. Preparation Sheet

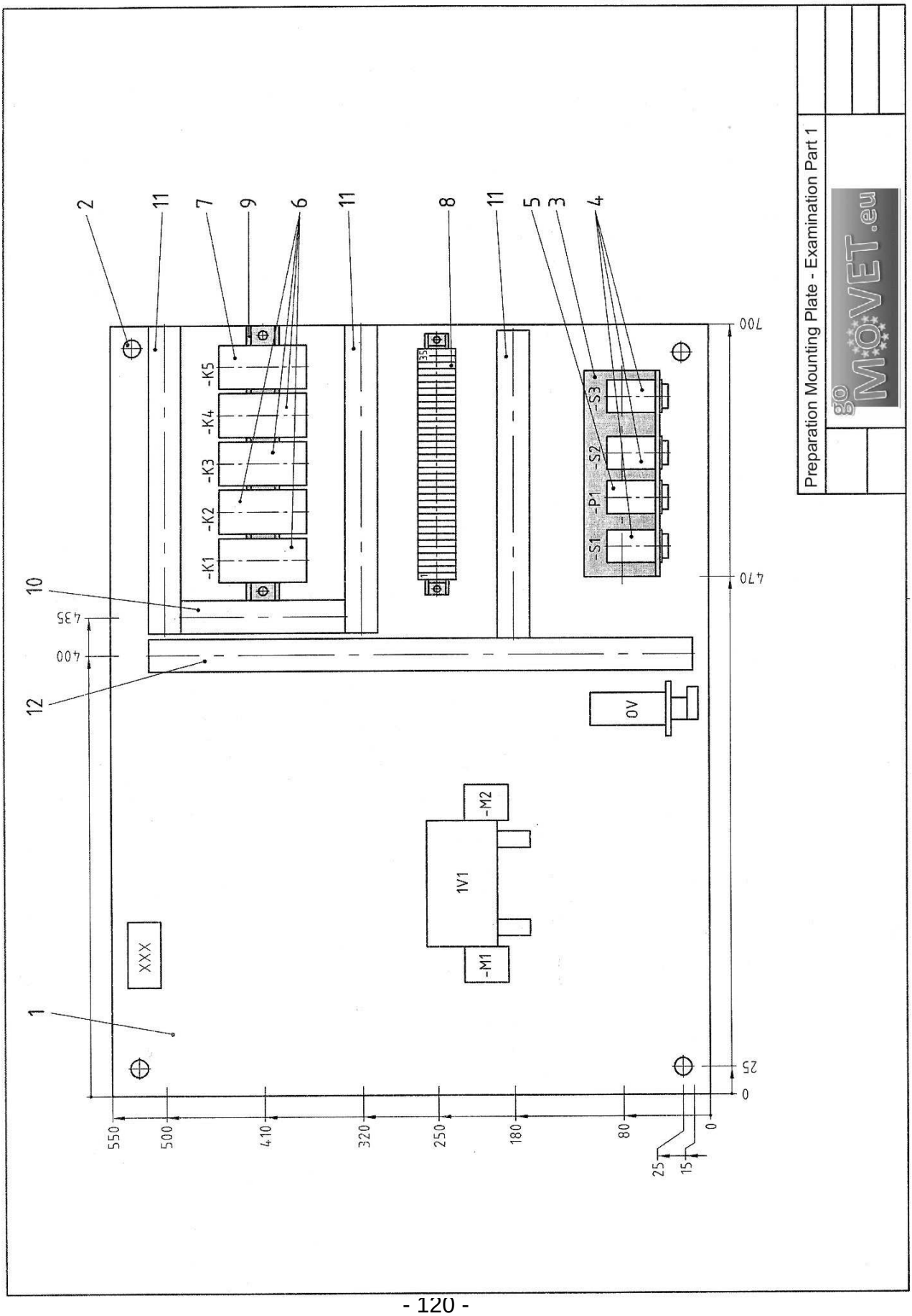
MOVET II

Examination Part 1

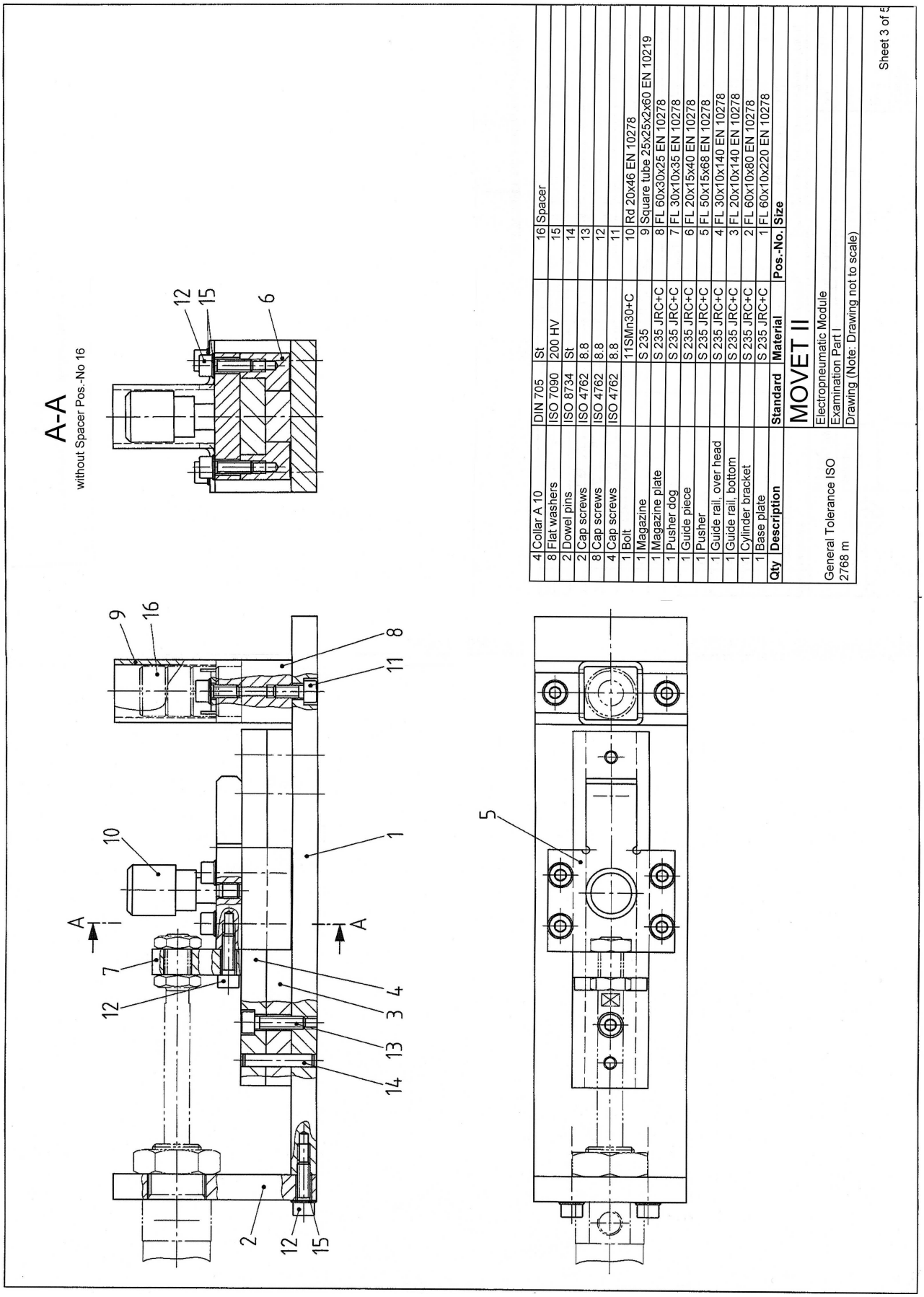
Preparation Sheet	**Electro pneumatic Module**

Running number	Number	Name from the components	Piece number
1	1	Mounting plate	1
2	4	Spacer bolts	2
3	1	Double-acting cylinder	
4	1	5-way pneumatic valve	1V1
5	1	3-way pneumatic valve	0V
6	1	Push button angle plate	3
7	3	Push button	4
8	1	Control lamp	5
9	4	Relay	6
10	1	Timer on delay relay	7
11	1	Modular terminal block	8
12	1	Mounting rail	9
13	5	Cable channels	10,11,12
14	2	Throttle check valve	
15	2	Proximity switches	
16	6m	Pneumatic hose	
17		Bridge for modular terminal block	
18	10m	Wire conductor	
19	50	Cable end sleeve	
20	25	Cable tie	
21	20	Sticker	
22	2	Connecting cable	

3. Preparation Mounting Plate

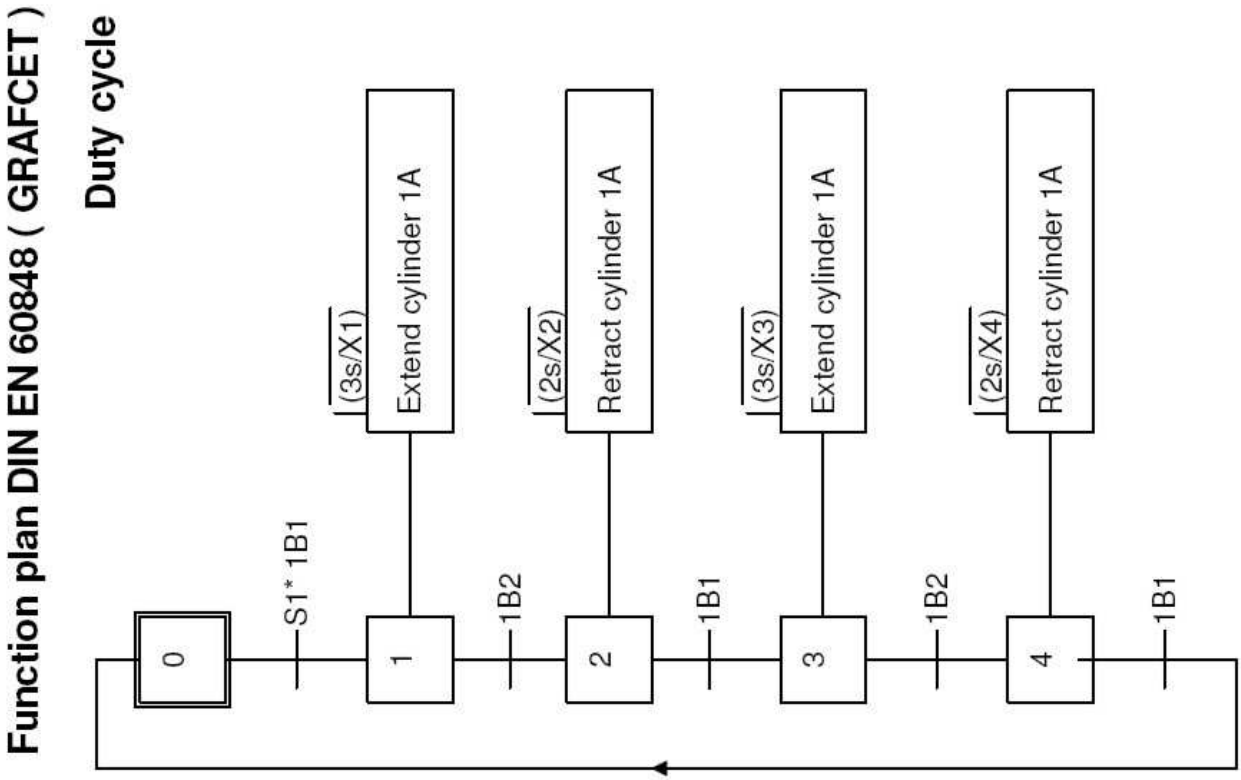


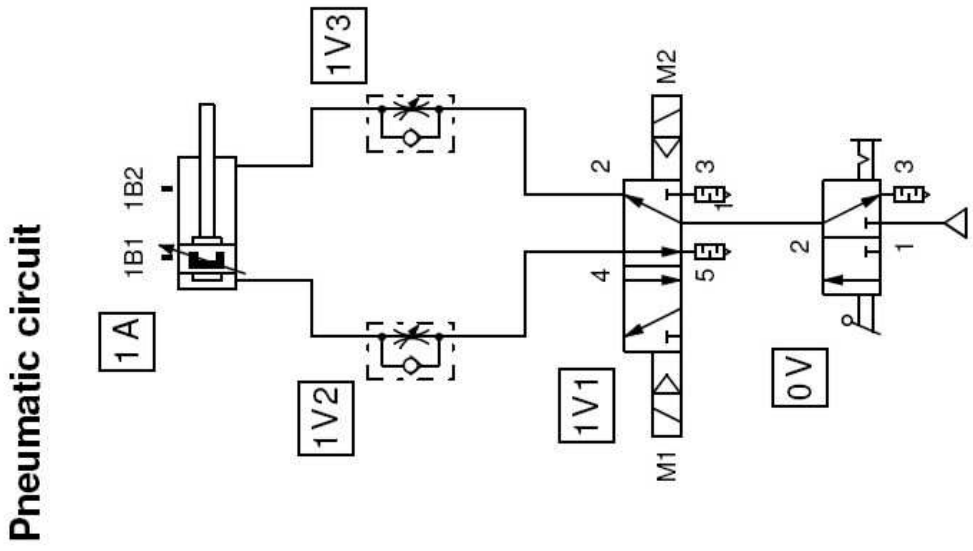
4. Drawing of the Mechanical Unit



Qty	Description	Standard	Material	Pos.-No.	Size
4	Collar A 10	DIN 705	St	16	Spacer
8	Flat washers	ISO 7090	200 HV	15	
2	Dowel pins	ISO 8734	St	14	
2	Cap screws	ISO 4762	8.8	13	
8	Cap screws	ISO 4762	8.8	12	
4	Cap screws	ISO 4762	8.8	11	
1	Bolt		11SMn30+C	10	Rd 20x46 EN 10278
1	Magazine		S 235	9	Square tube 25x25x2x60 EN 10219
1	Magazine plate		S 235 JRC+C	8	FL 60x30x25 EN 10278
1	Pusher dog		S 235 JRC+C	7	FL 30x10x35 EN 10278
1	Guide piece		S 235 JRC+C	6	FL 20x15x40 EN 10278
1	Pusher		S 235 JRC+C	5	FL 50x15x68 EN 10278
1	Guide rail, over head		S 235 JRC+C	4	FL 30x10x140 EN 10278
1	Guide rail, bottom		S 235 JRC+C	3	FL 20x10x140 EN 10278
1	Cylinder bracket		S 235 JRC+C	2	FL 60x10x80 EN 10278
1	Base plate		S 235 JRC+C	1	FL 60x10x220 EN 10278

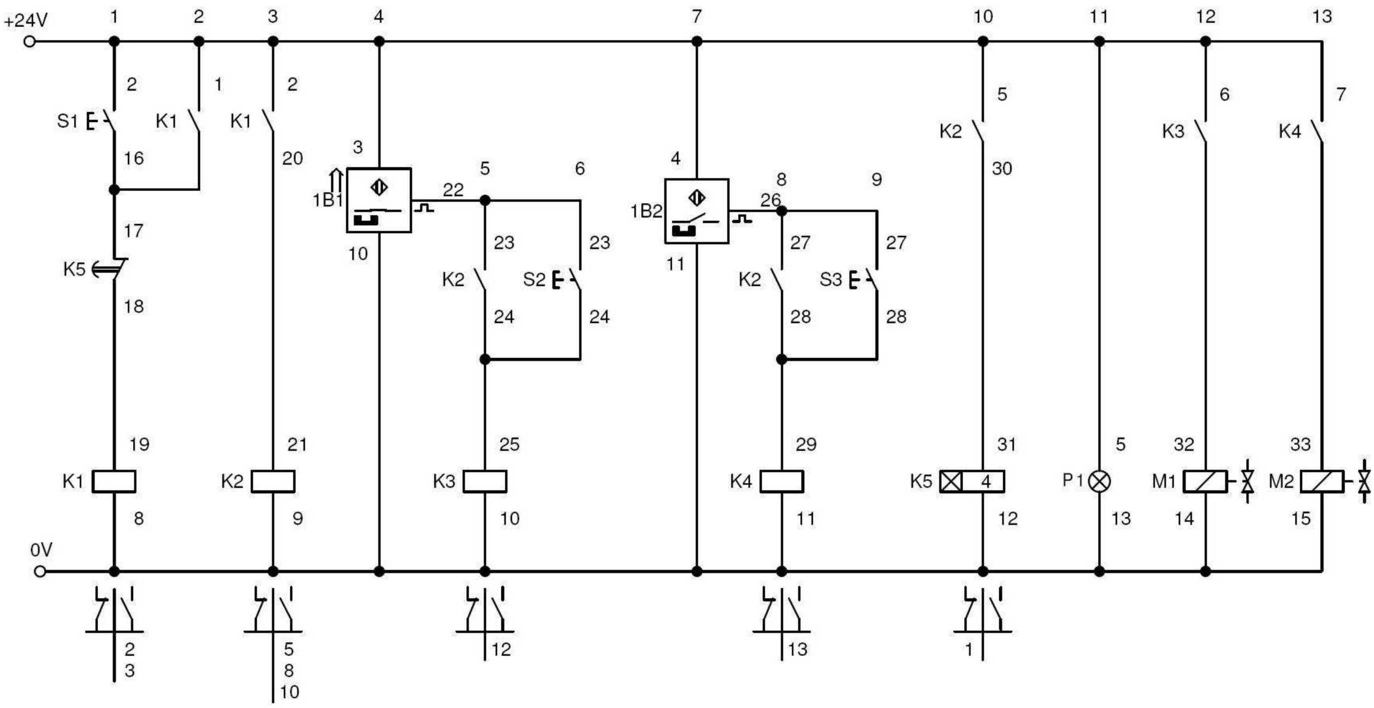
5. Pneumatic Circuit





6. Electrical Circuit

Electrical circuit



7. Terminal Strip

Terminal strip

Terminal number	Destination (top): Component	Destination (top): Pin No.	Link	Destination (bottom): Component	Destination (bottom): Pin No.
1	K1	13	o	24 V	+
2	K1	23	o	S1	3
3			o	1B1	+
4			o	1B2	+
5	K2	33	o	P1	X1
6	K3	13	o		
7	K4	13	o		
8	K1	A2	o	0 V	-
9	K2	A2	o		
10	K3	A2	o	1B1	-
11	K4	A2	o	1B2	-
12	K5	A2	o		
13			o	P1	X2
14			o	M1	A2
15			o	M2	A2
16	K1	14	o	S1	4
17	K5	15	o		
18	K5	16	o		
19	K1	A1	o		
20	K1	24	o		
21	K2	A1	o		
22			o	1B1	bl
23	K2	13	o	S2	3
24	K2	14	o	S2	4
25	K3	A1	o		
26			o	1B2	bl
27	K2	23	o	S3	3
28	k2	24	o	S3	4
29	K4	A1	o		
30	K2	34	o		
31	K5	A1	o		
32	K3	14	o	M1	A1
33	K4	14	o	M2	A1
34			o		
35			o		

Electrical circuit for triple-pole proximity switches

Electrical circuit for double-pole proximity switches

Pneumatic circuit

Function plan DIN EN 60848 (GRAFCET)
Duty cycle

8. Inspection by Apprentice

MOVET II	Name
Electro pneumatic Module	
Inspection by apprentice	Company

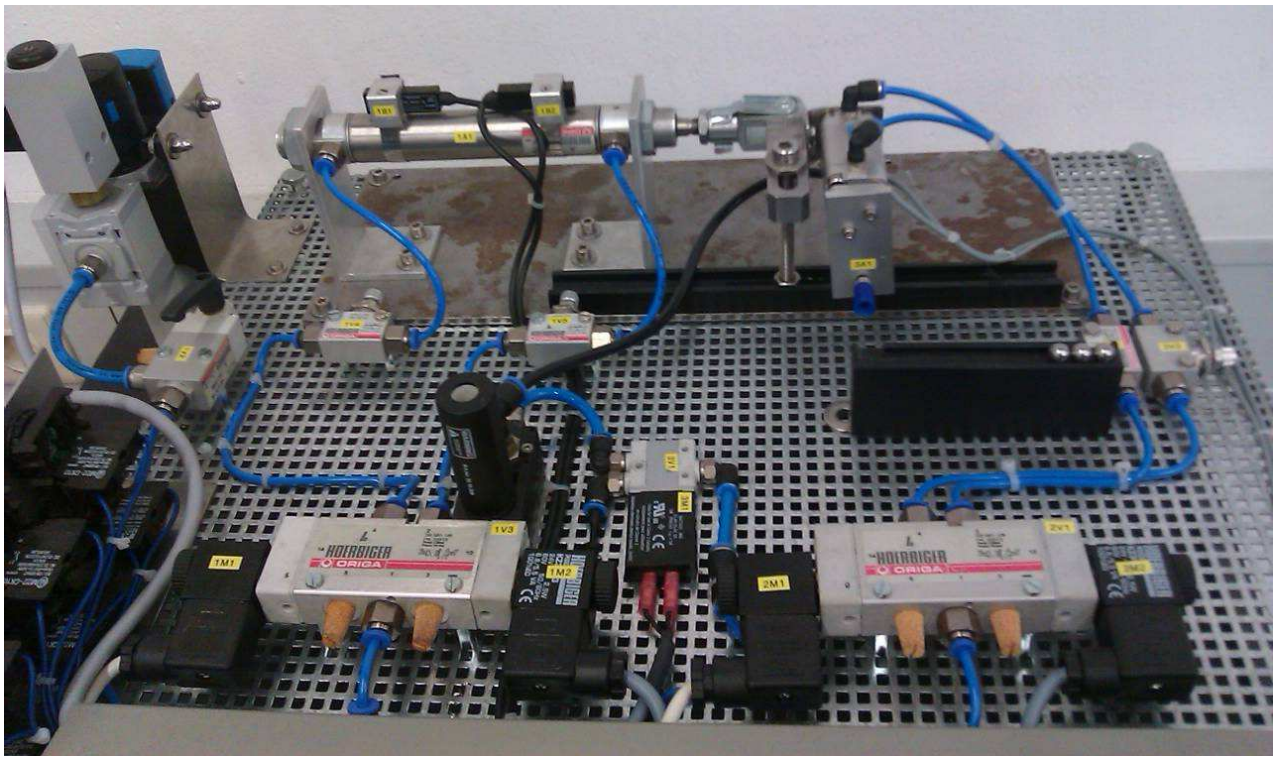
No.	Mechanical Assembly with Functional Control (function) Rating 10 or 0 points	
1	Overall function of the mechanical unit with control function, required pressure (min. 4 bar), cylinder 1A mounted, unit manufactured according to drawing, all fasteners tight	
	Remove piston rod of cylinder 1A from mechanical unit, check the control function without mechanical components	
2	The functional process follows the function chart (according to GRAFCET).	
	Turn off the electric power supply.	
3	Test the function of the cylinder 1A according to the circuit plan by using the hand assisted device.	
	Interim result divisor 0.3	
	Result of function	
		D1

No.	Inspection of the Pneumatic Components Rating 10-9-7-5-3-0 points	
1	Professional installation and positioning of all pneumatic components	
2	Correct connections of all pneumatic components	
3	Professional installation and fastening of all pneumatic hoses	
4	Proper adjustment of the extension time of the piston rod of cylinder 1A	
5	Proper adjustment of the retraction time of the piston rod of cylinder 1A	
6	Proper adjustment of the extended end-position cushion	
7	Proper adjustment of the retracted end-position cushion	
8	Leak-tightness of all pneumatic connections	
	Interim result divisor 0.8	
	Result of pneumatic	
		D2

No.	Inspection of the Electrical Components Rating 10-9-7-5-3-0 points	
1	Correct installation of all electrical connections according to the electrical circuit	
2	Correct positioning of all bridges	
3	Professional installation and fastening of all electrical wires	
4	Professional installation and positioning of the proximity switches	
5	Complete and correct identification of all components	
	Interim result divisor 0.5	
	Result of electric	
		D3

Final Result (D1 + D2 + D3) / 3	

Handling Module company



Electropneumatic Module

Contents

1. Description of work assignment

MOVET II Handling module	
Description of work assignment	**Electropneumatic Module**

Problem

For a fully automated quality control of ball bearing rollers (balls) a handling system with vacuum technology can be used. A vacuum nozzle has to hold balls under axial acceleration / deceleration. Using a test set-up three different nozzles should be tested.

Work order handling device

Your task is to carry out the pneumatic hosing and the electrical wiring using the existing plan. Consider the movements of the cylinders. All settings and adjustments are carried out as described.

Functional description of the handling module

In magazine 1, the balls are stored. Cylinder 2A1 extends and the vacuum nozzle picks up the first ball out of magazine 1. After two seconds cylinder 2A1 retracts. Cylinder 1A1 extends and cylinder 2A1 moves out again. The vacuum is switched off and the ball is put into magazine 2. After two seconds cylinder 2A1 retracts. Cylinder 1A1 moves back to its ground position. This system can be operated either in single mode (S1), automatic mode (S2) or single-step mode (S3).

Setting conditions

To achieve a low cycle time, the movement cycle (see GRAFCET) should be performed with the highest possible speed. Make sure that the ball is held safely during the cycle. All cylinder movements have to be cushioned in its end positions. Timers should be adjusted according to GRAFCET.

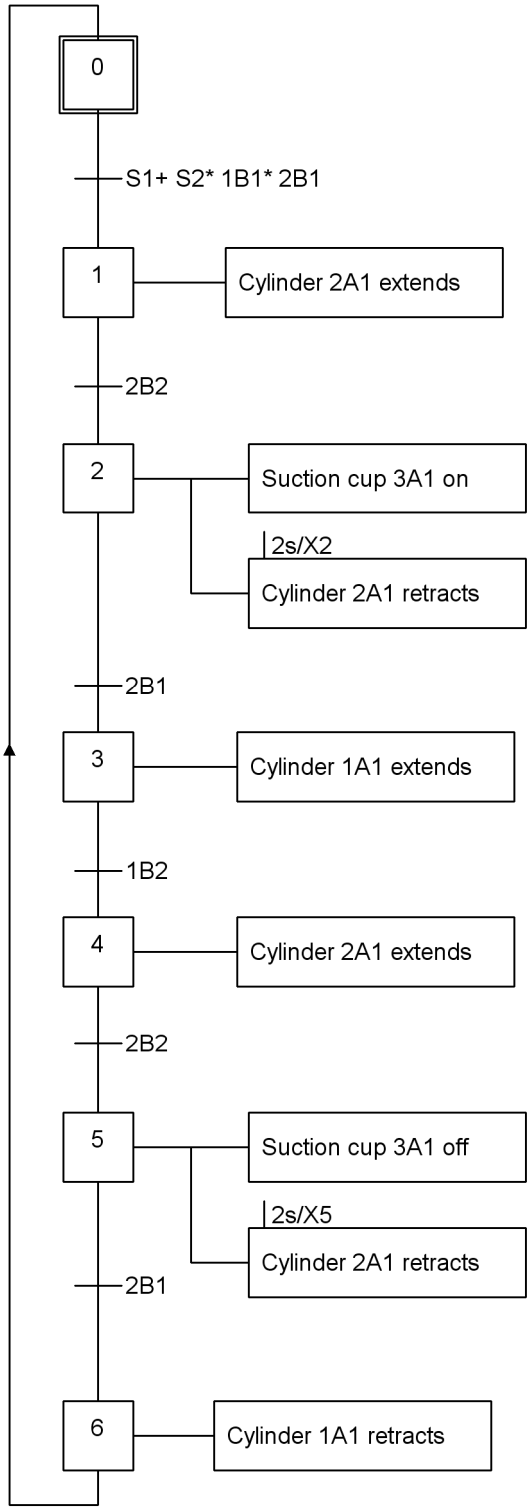
Testing

Carry out test runs for the 3 different nozzles with three different cycle times (slow, medium, fast). Document the results and develop a recommendation.

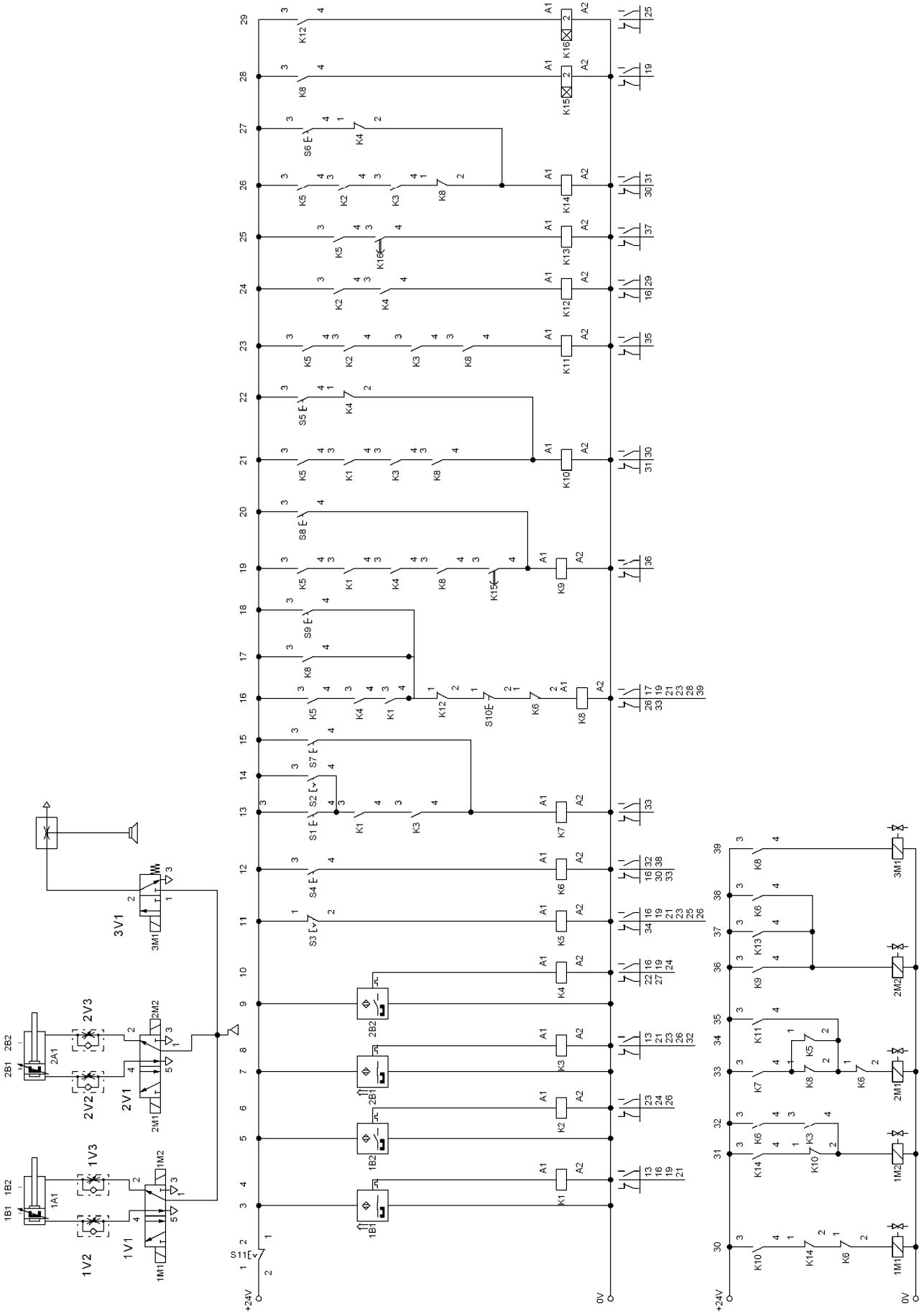
Presentation to the client

Present the system, which you have installed to the client. Explain your decision for the chosen nozzle and discuss your solution with the customer

2. Function plan DIN EN 60848 (GRAFCET)



3. Pneumatic and Electrical Circuit



4. Terminal Strip

Terminal strip																												
Destination	Pin No.							S2 4	S7 4	K8 14		S8 4	K4 32	K4 52	K5 71	K5 72			K3 54		K13 14		
	Component																						
Destination	Pin No.	K1 A1	K2 A1	K3 A1	K4 A1	S1 4	K3 14	K1 24	S9 4	K15 14	K8 34	K8 52	K8 71	K8 72	K11 14	K6 22	K10 22	K6 42	K9 14	K6 54	K8 84		
	Component																						
Terminal Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
Link		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Destination	Component	1B1	1B2	2B1	2B2	K1	K7		K12	K9	K10	K14	K7		K6	1M1	1M2	2M1		2M2	3M1		
	Pin No.					13	A1		11	A1	A1	A1	14		41	1	1	1		1	1		

Terminal strip															
Destination	Pin No.	K2 A2	K4 A2	K6 A2	K8 A2	K10 A2	K12 A2	K14 A2	K16 A2	1M2 2	2M2 2				
	Component														
Destination	Pin No.	K1 A2	K3 A2	K5 A2	K7 A2	K9 A2	K11 A2	K13 A2	K15 A2	1M1 2	2M1 2	3M1 2			
	Component														
Terminal Number		-	-	-	-	-	-	-	-	-	-	-	-		
Link		0	0	0	0	0	0	0	0	0	0	0	0		
Destination	Component	0V	1B1	1B2	2B1	2B2									
	Pin No.	-	-	-	-	-									

Terminal strip																												
Destination	Pin No.																											
	Component		K8	K12	K10	K14	K6	K7	K11	K9	K13	K6	K8															
			63	23	13	23	33	13	13	13	13	53	83															
Destination	Pin No.	S11 11	S11 12	S9 3	K5 23	S8 3	K5 33	S5 3	K5 43	K2 23	K5 53	K5 63	S6 3															
	Component																											
Terminal Number		+	+	+	+	+	+	+	+	+	+	+	+															
Link		0	0	0	0	0	0	0	0	0	0	0	0															
Destination	Component	24V	1B1	1B2	2B1	2B2	S3	S4	S1	S2	S7	K5	K8															
	Pin No.	+	+	+	+	+	1	3	3	3	3	13	13															

Report: Work order

Please tick off! (bitte abhaken!)

Explanation of the problem:

- o Explanation of the general task
- o Nozzles are tested holding balls
- o Low cycle time/ highest possible speed

Presentation of the Electro pneumatic system

- o After the start button is pushed the vacuum nozzle extends to its front position (X-axis) and picks a workpiece (ball).
- o Reaching the front position the suction cup sucks and retracts with the sucked work piece after two seconds.
- o Then it moves to the upper end position extends to its front position and ends sucking. After the work piece is placed (2 seconds) the system moves back in its initial position.

Additional task

- o Change the speed of extending/retracting cylinder 2A1
- o The cylinder 2A1 should stay three(longer/shorter) seconds in front position
- o Change the wiring to K15/K16 completely including an explanation

Part 1: Explanation: 5 minutes

- o good
- o non sufficient

Part 2: Discussion: 5 minutes

- o good
- o non sufficient

Part3: Additional Task

- o good
- o non sufficient

company expert	teacher
signature	signature

Questionnaire

Tick off asked questions and if answered satisfactorily

	asked	answered
1. Explain the general task of the handling module.	☐	☐
2. Which suction nozzle did you choose? Explain why.	☐	☐
3. Describe the procedure of the entire system with the GRAFCET diagram.	☐	☐
4. When putting the unit under pressure, what has to be considered? What dangerous situations could happen? (occur, arise)	☐	☐
5. Describe (explain…, what is…) the function of the push button 1S1.	☐	☐
6. Describe the function of the switch 1S2.	☐	☐
7. What do you need the time relay K15 for? Please explain.	☐	☐
8. What do you need the time relay K16 for? Please explain.	☐	☐
9. In which situation do you use the hand assisted device at valve ___ ?	☐	☐
10. Why do you need a terminal block?	☐	☐
11. What did you have to consider, when mounting the pneumatic hoses?	☐	☐
12. What did you have to consider, when mounting the electrical wires?	☐	☐
13. How do you adjust the speed (velocity) of the piston rods?	☐	☐
14. How do you adjust the end position cushion?	☐	☐
15. How did you adjust the proximity switches?	☐	☐
16. How is the vacuum at the suction nozzle produced?	☐	☐
17. What possibilities do you have to find electrical failures?	☐	☐
18. How can you see that the relay is activated?	☐	☐
19. Start the system in the single mode. Does the handling unit work according to the work order?	☐	☐
20. Start the system in the continuous mode. Does the handling unit work according to the work order?	☐	☐
21. After the current gets lost, how the system gets in its initial position?	☐	☐
22. What is the function of the valve 3V1?	☐	☐
23. Explain the function of emergency stop?	☐	☐
24. What happens in the case of loss of air/ What happens if the pressure sensor gives a signal?	☐	☐
25. What happens if time relay (K12) becomes defect?	☐	☐
26. How is the speed of extension adjusted?	☐	☐
27. How is the device driven in the initial position?	☐	☐
28. How can the power of a cylinder be adjusted?	☐	☐
29. Comment the Emergency-Stop function!	☐	☐
30. What happens if the manometric switch shows “Druck n.i.O.” during operation?	☐	☐
31. What happens if the specified-time relays K12 is not working?	☐	☐
32. How become the end positions of the piston rods sampled?	☐	☐
33. How can I see that the sensor (end position of a cylinder) is activated?	☐	☐
34. Cylinder 1A1 is not extending -> how do I start debugging? -> which causation can it have?	☐	☐

GD Bildung und Kultur
Programm für lebenslanges Lernen

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

goMOVET.eu

Certificate

Module EP

Ms/Mr first name last name

born dd.mm.yyyy

has successfully taken part in

90 hours of Electro-Pneumatics training

at

Städtische Berufsschule für Fertigungstechnik München (BSFT)

and

Bayerische Motorenwerke AG (BMW),

from 16th of January 2012 to 3rd of February 2012.

She/He has done 30 hours of training at BSFT, there she/he has planned, simulated and carried out automation technology with electro-pneumatics.

During the 60 hours of training at BMW she/he carried out work orders including a training on the job phase.

She/He has passed the paper and pencil test and the skills demonstration successfully. All communication during the training and the team work was in English language.

Herewith we certify that

7.2 He/She can master the selection of hardware, software and industrial components for mechatronic systems (sensors, actuators, valves, relays, interfaces, communication procedures). He/she can provide and test simple software control programs (SPS) and develop and design simple control programms according to production process requirements (adaption of Competence level description 7.2 according to VQTS model)

These Learning Outcomes are associated to EQF Level 4.

Munich, 3rd of February 2012

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BSFT

Seidenader Group

MTU Aero Engines

SWM

BMW

Technische Universität München

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